UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1936

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UNITED STATES DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS

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REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1936

By J. T. Jardine and W. H. Beal [1]

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INTRODUCTION

The year 1936 represented an epoch in the history of the agricultural experiment stations, namely, the successful inauguration of a program of effective research under the Bankhead-Jones Act, approved June 29, 1935, which materially increased the Federal funds available for station work and the extension of coordinated and cooperative agricultural research on a scale never before attempted. The administration of this act was entrusted by the Secretary of Agriculture to the Office of Experiment Stations by Memorandum 689 of March 16, 1936, as follows:

The general administration of the Bankhead-Jones Act, approved June 29, 1935 (49 Stat., pp. 436–439), has been assigned to the Office of Experiment Stations. This will include the planning and coordination of the research program of the Department under the "Special Research Fund" and the supervision of the payments to the State Agricultural Experiment Stations.

These activities, together with the increased emphasis now being given to the regional approach to major research problems, indicate the necessity of having a central authority in the Department to promote cooperation in the planning and coordination of research, both within the Department and with the States and other agencies participating in agricultural research. To meet this need, the Chief of the Office of Experiment Stations is hereby designated Director of Research for the Department.

The Director of Research will have general direction of the planning, development, and coordination of the research program of the Department, and will

[1] With the collaboration of other members of the Office staff.

cooperate with the bureaus in the planning and execution of research work. He will continue to be responsible for present activities of the Office of Experiment Stations, including the administration of Federal grants to the States for the agricultural experiment stations, and coordination of research of the States under these grants, and the coordination of such projects with research of the Department along the same lines.

Under this and previous authorizations, the Office of Experiment Stations administered Federal funds provided by the Hatch, Adams, Purnell, Bankhead-Jones, and supplementary acts for the support of agricultural experiment stations in the several States and in Alaska, Hawaii, and Puerto Rico, aided in every practicable way in coordinating the work of the Department with that of the stations, and prepared and published the usual annual report on the work and expenditures of the stations as required by law.

A satisfactory program of research under the Bankhead-Jones Act which will eventually increase the annual income of the stations from Federal sources to about $7,400,000 was agreed upon by the stations early in the year.

BANKHEAD-JONES ACT

The Bankhead-Jones Act authorized for the fiscal year 1936 a total of $600,000 allotted to the States, Territories, and Puerto Rico on the basis of their respective rural populations. An appropriation was made for this purpose in the Second Deficiency Appropriation Act, approved August 12, 1935.

The allotments of Bankhead-Jones funds to the several States and Territories in 1936 were as follows:

TABLE 1.—*Bankhead-Jones allotments to stations, 1936*

Station	Amount	Station	Amount	Station	Amount
Alabama	$20,673.78	Louisiana	13,783.36	Ohio	$23,253.69
Alaska	559.12	Maine	5,173.04	Oklahoma	17,112.71
Arizona	3,105.64	Maryland	7,137.62	Oregon	5,043.95
Arkansas	15,995.80	Massachusetts	4,545.55	Pennsylvania	33,672.38
California	16,485.49	Michigan	16,741.96	Puerto Rico	12,138.04
Colorado	5,607.74	Minnesota	14,199.41	Rhode Island	565.96
Connecticut:		Mississippi	18,162.85	South Carolina	14,866.24
New Haven	2,582.26	Missouri	19,241.95	South Dakota	6,108.11
Storrs	2,582.26	Montana	3,875.79	Tennessee	18,695.97
Delaware	1,252.55	Nebraska	9,694.15	Texas	37,341.19
Florida	7,700.41	Nevada	615.16	Utah	2,625.92
Georgia	21,880.73	New Hampshire	2,089.30	Vermont	2,617.90
Hawaii	2,296.60	New Jersey	7,631.46	Virginia	17,786.14
Idaho	3,429.64	New Mexico	3,440.25	Washington	7,378.93
Illinois	21,684.13	New York:		West Virginia	13,453.36
Indiana	15,680.65	Geneva	2,245.79	Wisconsin	15,056.22
Iowa	16,213.66	Ithaca	20,212.12	Wyoming	1,689.88
Kansas	12,512.74	North Carolina	25,657.00		
Kentucky	19,734.51	North Dakota	6,168.94	Total	600,000.00

Unlike the earlier acts authorizing Federal funds in support of the experiment stations, the Bankhead-Jones Act requires that each State and Territory shall make available from other than Federal sources funds equal in amount to those received under the Bankhead-Jones Act for each fiscal year, such offset funds to be used for agricultural research and the facilities necessary for its prosecution.

In accordance with plans promulgated by the Secretary of Agriculture in consultation with representatives of the experiment stations in the several States and Territories, the Bankhead-Jones fund

retains its identity for the support of definite research projects submitted for review and approval by the Office of Experiment Stations before expenditures from the funds under the act are made. The act designates a certain percentage of the sum appropriated for administration of the act by the Office.

From September 1, 1935, to the close of the fiscal year 1936, a Bankhead-Jones program of 360 research projects was agreed upon, and satisfactory progress was made in effectively integrating and coordinating research under the act with research under the other Federal acts, State funds, and with the Department as provided by the law.

The requirements of the act regarding State offset funds were met satisfactorily out of the $11,000,000 or more available during the year to the stations from other than Federal sources. In individual States, however, the amount from other than Federal sources was much less than the average in comparison with the total funds from the Federal acts, and while sufficient to meet requirements of the Bankhead-Jones Act for the fiscal year 1936 may be insufficient in future years unless additional funds from State sources are provided.

Approximately one-sixth of the Bankhead-Jones funds for the fiscal year 1936 was devoted to some 42 station projects in agricultural economics concerned with adjustment in production by regions and type-of-farming areas better to meet changing economic conditions; marketing agricultural products, including methods and practices; and soil and water conservation and land use. About one-sixth of the total was assigned to some 60 projects relating to animal production, mainly in the fields of nutrition of the larger animals and poultry. These dealt largely with vitamins and mineral nutrition and are mainly of fundamental character and of broad application. Another line of research receiving a relatively large allotment was that dealing with farm pastures and ranges. About $68,000 was assigned to such research, much of which was coordinated and carried on cooperatively with the Department of Agriculture. In the northeastern region, for example, the State stations have set up projects dealing with certain phases of the pasture problem which are of local nature but should be, and are now, coordinated with the research program of the regional pasture laboratory (p. 4) under the Bankhead-Jones Act.

About $62,000 was allotted projects on breeding and production of field crops, particularly those concerned with plant genetics and breeding for improved quality and varieties. Approximately $40,000 was assigned to projects in animal genetics. This is considered especially significant in view of the limited opportunity for thoroughgoing research in this field in the past. It is recognized that progress may be slow in this field, and every effort has been made to organize the research on a conservative basis rather than to attempt too large a program at the beginning.

SPECIAL RESEARCH FUND, DEPARTMENT OF AGRICULTURE

The Bankhead-Jones Act makes available to the Department of Agriculture a special research fund in addition to increased funds for the experiment stations. This fund is available, one-half for

research projects of the Department and one-half for the establishment and operation of research laboratories in the major agricultural regions at places selected by the Secretary. A total of $400,000, including $8,000 for administration, was made available for these purposes during the fiscal year 1936.

SPECIAL RESEARCH PROJECTS

The special research program for 1936 included 32 projects, involving participation of 10 bureaus of the Department. Of the 32 projects, 5 were short-time undertakings, completed by June 30, 1936. It was expected that 6 additional short-time projects would be completed early in the first half of the fiscal year 1937. Most of the other projects are of a fundamental character, which should be continued over a longer period, subject to redirection as new findings warrant.

In the development of projects under the special research fund, every effort was made to secure effective cooperation of research workers regardless of organization lines. For example, an investigation of grain storage on the farm was undertaken cooperatively by the Bureaus of Agricultural Engineering, Agricultural Economics, and Plant Industry. Since the problems to be met vary in different sections, seven State experiment stations were brought into the research through formal cooperative agreements. Another intensive fundamental research project concerning plant viruses was undertaken cooperatively by specialists of the Bureaus of Plant Industry and Chemistry and Soils. Projects were undertaken involving like cooperation of the Bureaus of Animal Industry and Dairy Industry and of Agricultural Economics and Dairy Industry. Similar cooperation between the Department and outside agencies on several projects made available physical plant facilities and technical skill not available in the Department.

REGIONAL LABORATORIES

The first steps in the establishment of regional laboratories in accordance with the provisions of the Bankhead-Jones Act were taken with chiefs of bureaus of the Department and directors of the State experiment stations. The subject was given special consideration during the meetings of the Association of Land-Grant Colleges and Universities in November 1935.

Following negotiations with the land-grant colleges and experiment stations, the Department issued a statement of policy on December 19, 1935, which embodied suggestions from its bureaus and recommendations from the State stations approved by the executive body of the Association of Land-Grant Colleges and Universities. Among other things, it provided, as a basis for the activities of the regional laboratories, that the Secretary of Agriculture receive suggestions from the experiment station directors and from bureau chiefs in the Department; that he locate such laboratories solely with regard to the technical requirements and the facilities available; and that the Department and the State experiment stations enter into memoranda of understanding regarding the work to be done, the cost of doing

it, the sources of the funds, and the coordination of the laboratory research with regular activities of the States and the Department, Federal, and State specialists to cooperate in preparing detailed plans.

On the basis of the above general understanding, three laboratories were established and work began at them during the year, namely, a laboratory for study of problems of truck-crop breeding, near Charleston, S. C.; one for study of pasture improvement, at State College, Pa.; and another for investigation relating to utilization of soybean products, at the University of Illinois.

FEDERAL-GRANT FUNDS TO THE STATES

During the year ended June 30, 1936, Federal-grant funds to the States, Alaska, Hawaii, and Puerto Rico amounted to $4,995,000, including $600,000 under the Bankhead-Jones Act and $90,000 to each State, $15,000 to Alaska, and $30,000 each to Hawaii and Puerto Rico under the Hatch, Adams, and Purnell Acts. The total of $4,995,000 of Federal funds formed a substantial part of the grand total of $16,425,489 available to these experiment stations from all sources during the year. The remainder, amounting to $11,361,178, was derived from State appropriations and endowments, emergency allotments, sales receipts, and other miscellaneous sources.

NON-FEDERAL SUPPORT OF THE STATIONS

The income of the stations from other than Federal sources during the year was as follows:

TABLE 2.—*Income of the experiment stations from other than Federal sources for the fiscal years 1935 and 1936*

Station	1935	1936	Station	1935	1936
Alabama	$176,508.83	$270,158.54	Nevada	$11,996.03	$13,357.07
Alaska	9,198.43	8,633.50	New Hampshire	65,723.80	58,214.60
Arizona	86,878.75	100,298.42	New Jersey	463,018.16	455,192.50
Arkansas	75,161.90	81,526.71	New Mexico	56,249.34	54,417.63
California	877,093.22	926,767.62	New York:		
Colorado	140,027.52	181,063.64	Cornell	580,305.72	625,207.36
Connecticut:			State	357,532.91	377,073.50
State	216,214.07	235,065.90	North Carolina	124,912.85	144,763.66
Storrs	42,491.10	44,319.03	North Dakota	84,418.64	102,446.99
Delaware	35,938.20	40,781.26	Ohio	804,404.55	815,215.92
Florida	357,644.99	423,330.84	Oklahoma	139,430.39	142,613.94
Georgia	42,664.03	39,793.34	Oregon	205,934.92	229,842.34
Hawaii	24,066.95	37,703.40	Pennsylvania	167,130.92	155,839.57
Idaho	27,860.86	36,773.13	Puerto Rico	111,328.25	121,355.00
Illinois	425,044.04	417,057.35	Rhode Island	7,897.70	8,398.92
Indiana	734,003.48	817,732.07	South Carolina	132,589.09	158,007.59
Iowa	246,891.95	265,675.01	South Dakota	39,217.74	45,698.65
Kansas	170,357.65	192,266.59	Tennessee	36,545.74	38,278.22
Kentucky	252,075.44	294,965.54	Texas	531,425.81	611,760.82
Louisiana	108,618.96	117,876.58	Utah	66,656.61	56,511.00
Maine	49,594.01	56,359.79	Vermont	23,351.18	24,233.37
Maryland	84,899.63	112,225.31	Virginia	88,912.31	92,964.54
Massachusetts	232,394.72	258,886.96	Washington	195,857.69	116,260.66
Michigan	271,345.14	266,064.57	West Virginia	81,387.84	87,626.60
Minnesota	419,462.61	430,279.77	Wisconsin	410,296.09	407,237.34
Mississippi	166,081.47	161,194.38	Wyoming	120,043.53	124,598.58
Missouri	128,094.52	156,769.34			
Montana	139,617.74	135,579.20	Total	10,615,325.84	11,361,178.71
Nebraska	168,527.82	184,914.55			

The income of the stations from other than Federal sources, $11,361,178, was about 69 percent of the total, and $745,852, or approximately 7 percent more than for the preceding year. The greater income for the year 1936 resulted from increases of $134,301 in the amount of balances carried over from the preceding year; $559,283 in State appropriations and allotments; $126,375 in fees; and $74,598 in sales receipts. These increases were offset, to the extent of $148,705, by decreases in miscellaneous income. Of the 53 experiment stations 40 reported an increase for the year in the support from State and other non-Federal sources, and the reduction in income from these sources reported by the 13 other stations was, in all cases except one, not very significant. The contribution of the Federal Government for the support of the stations for the year was approximately $1 for every $2.25 received from non-Federal sources. During the year many of the stations continued to be benefited also from the expenditure of emergency funds for repairs and improvements of the station equipment, and from allotments by the Department of Agriculture for cooperative work with the stations, but complete data on the amount so used and how distributed are not available.

Details of income and expenditures of the experiment stations during the fiscal year 1936 will be found on pages 182 to 197.

RESEARCH PROJECTS AND PROGRAMS

With the inauguration of work under the Bankhead-Jones Act, research programs and projects were extended to a wider field of activity than in previous years.

The 7,223 projects active during the year provided for research in almost every phase of agriculture and rural life, including land use, soils, and soil and water conservation; crop adjustment; economical production, distribution, marketing, and use of plant and animal products; improvement of the quality of such products; protection against animal and plant diseases, insects, and other pests; tenancy, taxation, and other matters affecting the efficiency of farm business management and the betterment of the rural home and rural life; and improved practices in human nutrition, home management, and other similar research. Some of the more important recent accomplishments of the experiment stations in these various lines are reviewed on pages 18 to 179.

During the year a total of 509 Adams projects as compared with 497 the previous year and 1,673 Purnell projects as compared with 1,697 the previous year were active. A total of 360 station Bankhead-Jones projects were agreed upon and approved. Two hundred and fifty-one new and revised Purnell projects and 63 new and revised Adams projects were approved.

The largest number of Purnell projects continued to be in the fields of agricultural economics, 360 with an estimated expenditure of $684,763, including 95 in farm management, 65 in marketing, 48 dealing with agricultural adjustment, 35 in taxation, and 32 in land economics. Other subjects in which there were a relatively large number of projects were animal production 240, home economics and horticulture 141 each, entomology 133, field crops 124, and plant pathology 103. The estimated expenditure of funds was roughly in proportion to the number of projects.

In accord with the tendency and the major objective of the plan for expending the Bankhead-Jones funds, 87, or 24 percent, of the projects were conducted in cooperation with Federal or State agencies. The projects were in most of the major fields of agriculture, but the largest numbers were concerned with subjects related to animal production, field crops, certain phases of agricultural economics relating to agricultural adjustment, marketing, land use, and pastures and ranges.

PROJECT OUTLINES

At various times the Office of Experiment Stations and station directors and research workers have considered the advantage of defining more clearly the essential points that should be covered in a project outline. In 1931 the Association of Land-Grant Colleges and Universities, through a report of its committee on experiment station organization and policy, attempted such a definition and it appears to have served a useful purpose. Using this and its long experience in dealing with project outlines as a basis, the Office of Experiment Stations has formulated and offers for consideration the following essential points to be covered in a research project outline, in the hope that it will be useful to those called upon to outline projects.

ESSENTIAL POINTS TO BE COVERED IN A RESEARCH PROJECT OUTLINE

1. *Title:* Make this a specific, brief, clear, adequate characterization of the work to be undertaken (such words as "Study of" or "Investigation of" should be omitted for brevity).

2. *Objective:* Clearly define the aims or immediate purposes which the project seeks particularly to accomplish.

3. *Reasons for undertaking the study:* Indicate the importance of the problem to agriculture or rural life, the activity or interest of any particular group of citizens in connection with it, the justification for its study at public expense, and the probable use to which the results will be put.

4. *Previous work and present outlook on the problem:* Briefly summarize prior related work at the institution and elsewhere, citing the more important pertinent contributions to the literature. Indicate present activity in this field. Give briefly the present status of the problem and set forth analytically the phases which need further study. Indicate the extent to which the project aims to meet this need.

5. *Procedure:* Indicate explicitly the essential working plans for field and laboratory research and the methodology and technique to be employed in attaining the proposed objectives. Where quantitative values are sought, the procedure followed should assure data susceptible of approved statistical analysis. Mention the specific phases of the project to be undertaken currently as distinguished from phases to be left for later attack, and indicate the place or places where the work is to be conducted.

6. *Probable duration:* State the length of time probably required to carry out the specific objectives of the project.

7. *Financial support:* Indicate the annual amounts apportioned to (1) salaries and (2) maintenance (based on careful analysis by the leader of the anticipated requirements for salary, labor, equipment, supplies, travel, other operating expenses, publication, etc.). Where more than one fund is used in support of the project, the estimated allotment from each fund should be indicated.

8. *Personnel:* Designate the leader or leaders in charge of the project or the chairman of the project committee. The other technically trained staff members who are assigned to work on the project should also be listed.

9. *Departments involved:* List each department or organized division in the institution contributing essential services or facilities to the work of the project. If there is an advisory, coordinating, or directing committee for the project, the facts should be indicated.

10. *Regional or national cooperation:* If the project is conducted as part of some particular formal or informal coordinated program of work with other institutions or agencies, state the facts. If the project is carried on under a written memorandum of understanding, state the facts, with date of such memorandum.

COORDINATION AND COOPERATION

The Bankhead-Jones Act laid a broader, firmer, and more positive basis for cooperation and coordination in the work of the Department, the experiment stations, and other research agencies.

As already indicated, specialists of the Department and the State stations continued to cooperate in efforts to plan and coordinate their research on sound and productive lines, with reference both to immediate requirements and long-time needs, and especially to develop coordination and cooperation under the Bankhead-Jones Act.

As usual, the State agricultural experiment stations worked closely with other State agencies, with local organized groups, with each other in regional groups, and with the Department individually and in regional and national groups in efforts to plan and coordinate their research. A total of 818 new or revised formal cooperative agreements between bureaus of the Department and the experiment stations were proposed. The agreements covered 731 major research undertakings. All the State experiment stations and all but one of the Department's research bureaus participated. There were also many informal cooperative agreements, some of them of major importance.

The increasing trend toward voluntary coordination of effort among research workers on problems of wide importance is illustrated by the establishment in 1935 of the Tobacco Disease Council and the Cotton Disease Council, each embracing all interested workers in the States concerned and in the Department of Agriculture. Conferences were held, arrangements were made for mutual assistance, and a future program was developed. Exchange of research outlines, annual reviews of progress, and further group planning were provided for. Definite improvement in the research programs has already resulted. In a similar way, horticulturists, entomologists, and plant pathologists at the Maryland, Pennsylvania, Virginia, and West Virginia Stations established a combined four-State attack on the orchard spray injury problem. A number of other promising group programs were launched during the year.

Certain regional and national cooperative research undertakings that had been started on an emergency basis as parts of the national recovery program in 1934 and 1935 were modified and expanded to meet more permanent requirements. These studies brought more closely together the parallel interests of plant- and soil-science research and those of crop- and animal-production research, with more thorough consideration of their economic and social influences. Studies of adjustments in farming by regions and type-of-farming areas from the standpoint of national agricultural adjustment received considerable attention in this connection, and were typical of the renewed and expanded efforts in cooperative research.

A general plan for further action was agreed upon by State and Federal representatives at the meeting of the Association of Land-

Grant Colleges and Universities in the fall of 1935 and formed the basis of widely extended cooperative research in regional adjustment in 1936. Among the State experiment stations, it was common to find from 5 to 10 subject-matter departments actively engaged in coordinating their studies to meet both State needs and national adjustment programs.

A very striking example of cooperation in the interest of agricultural investigation was the search for superior germ plasm as a basis for "creative development of new forms of life through plant and animal breeding", as epitomized by a committee of the Department with the widespread cooperation of the agricultural experiment stations and plant and animal breeders generally, in the Yearbook of the Department for 1936, to be continued in next year's Yearbook.

The establishment and operation of regional research laboratories under the Bankhead-Jones Act as already referred to was another significant development in cooperative research during the year.

INSULAR STATIONS

As in previous years the work of the Hawaii and Puerto Rico Stations was administered under the supervision of the Office of Experiment Stations. These stations, however, developed a greater degree of autonomy and strengthened and increased their affiliation with local research agencies as well as with bureaus of the Department of Agriculture.

HAWAII STATION

The policy of close coordination and gradual merging of the Federal experiment station in Hawaii and the station of the University of Hawaii was further developed during the year, and the two stations are now, in effect, one coordinated station, under the direction of O. C. Magistad.

The income of the station from regular appropriations and receipts for the fiscal year 1936 was $102,066, as compared with $85,044 for the previous year. This was made up of Hatch and Adams funds, $15,000 each; Bankhead-Jones funds, $2,297; direct appropriations for the Federal station through the Department of Agriculture, $32,066; and from sources within the Territory, $37,703. In addition, the station had the continued responsibility of administering and conducting research initiated under the following tax-fund orders:

No. 4, Taro Investigations in the Territory of Hawaii; no. 5, Liver Fluke Eradication in the Territory of Hawaii; no. 6, Rat Abatement Campaign in the Territory of Hawaii; no. 7, Development of Truck Farming and Improvement of Marketing Facilities for Farm Products in the Territory of Hawaii; no. 8, Development of Livestock Feed in the Territory of Hawaii; no. 9, Development of Tropical Fruits and Nuts in the Territory of Hawaii; and no. 10, Promotion of the Poultry Industry, Territory of Hawaii. Expenditures under these orders during the year amounted to $124,186.62.

With greater financial support, the station increased its personnel, added to its facilities for research, and started a number of new activities or lines of work. The personnel was expanded from 10

full-time and 7 part-time technical employees during 1935 to 47 full-time and 14 part-time during the year 1936. New divisions were set up in horticulture, plant pathology, and parasitology. Better quarters were provided for the station in the new agricultural building. A new laboratory and greenhouse was provided for investigations in plant pathology. A model barn and a food-processing laboratory were also made available for the purposes of the station. A 30-acre tract of land with adequate electric power and water for irrigation was transferred to the station for use as a substation. Activities of the station now permeate the entire Territory by reason of the 20 or more animal and field experiments being carried on cooperatively with Government and private agencies.

As heretofore, the major objective of the station work was to develop more fully the agricultural resources and possibilities of the island and to secure as far as practicable a more diversified and self-sustaining agriculture. To this end increased attention was given to crops which might be grown profitably in addition to sugarcane and pineapples. Quota restrictions on sugar and on pineapples have limited the expansion of these crops, while constantly increased yields tended to release areas of arable land. There appear to be possibilities for economical production of macadamia nuts, taro, papaya products, tomatoes, passion fruit, and asparagus, and for increasing beef production in the Territory.

Work under the tax orders was closely integrated with the research under the regular funds to best promote enterprises that show most promise in the development of a self-sustaining agriculture not only through introduction of new crops and development of crops for which research to date has shown possibilities, but by solving some of the problems confronting existing enterprises such as poultry, meat, and dairy production through control of diseases and the development of more economical feeds and management practices.

The soil survey was continued in cooperation with the Bureau of Chemistry and Soils, and cooperation with the Bureaus of Animal Industry and Biological Survey was developed.

As a whole, there was a material increase in effectiveness of the research work of the Hawaii Station, and a marked strengthening of Federal and Territorial relationship. The work of the central station was effectively extended through branch stations and cooperative experiments.

A review of the investigations during the year will be found in the annual report of the station for 1936.

The publications of the station during the year were Bulletins 74, The Edible Passion Fruit in Hawaii, by W. T. Pope; 76, Factors Affecting the Chemical Composition of Pasture Grasses, by D. W. Edwards and R. A. Goff (published in Hawaii); and 77, Some Fruits of Hawaii: Their Composition, Nutritive Value, and Use, by Carey D. Miller, Katherine Bazore, and Ruth C. Robbins (published in Hawaii); and Report of the Hawaii Agricultural Experiment Station, 1935.

The following articles were prepared for publication in outside journals: Mechanism of Organic Reactions—IV, Pyrolysis of Esters and Acetals, by E. M. Bilger and H. Hibbert (Jour. Amer. Chem. Soc., 58 (1936), no. 5, pp. 823–826); Results of Feeding Sprouted

Oats to Correct Sterility in Cattle and Swine, by L. A. Henke (Jour. Agr. Research, 51 (1935), no. 1, pp. 51–59); Is Fecundity in Swine Inherited? by L. A. Henke (Jour. Heredity, 26 (1935), no. 11, pp. 455–456); Possibilities of Enlarging and Improving our Beef Industry in Hawaii, by L. A. Henke (Hawaii. Sugar Planters' Assoc. Proc., 55 (1935), pp. 110–116); Bagasse and Paper Mulches, by O. C. Magistad, C. A. Farden, and W. A. Baldwin (Jour. Amer. Soc. Agron., 27 (1935), no. 10, pp. 813–825); and Seed Production Studies with Legumes in Hawaii, by C. P. Wilsie (Jour. Amer. Soc. Agron., 27 (1935), no. 10, pp. 784–790).

PUERTO RICO STATION

The Federal station at Mayaguez, under the direction of Atherton Lee, continued to develop and enlarge its work and cooperative relationships with other research agencies, and to increase the usefulness and effectiveness of the station in aid of Puerto Rican agriculture and that of the continental United States. To aid in coordinating the work of the insular station connected with the University of Puerto Rico and the Federal station at Mayaguez, a committee consisting of the directing heads of the experiment stations, the insular Department of Agriculture, and the College of Agriculture was appointed and was active in an advisory way as to the agricultural program and the allocation of research work to the several agencies. Research by bureaus of the Department in the island was largely cooperative, either formally or informally, with one or the other of the experiment stations.

Regular appropriations to the Federal station at Mayaguez for the fiscal year 1936 amounted to $37,245. In addition, the station continued responsibility for research undertaken with funds made available by the Puerto Rico tax-fund order no. 5. Expenditures under this fund for the fiscal year amounted to $70,932. With use of these funds closely coordinated a number of investigations of benefit to agriculture in the continental United States as well as in Puerto Rico were possible. With increased funds it was possible to add much-needed facilities and equipment for research, such as a screened plant quarantine house and a screened greenhouse for protection against insects.

In cooperation with the Bureau of Plant Industry, the collection of rotenone-producing plants was increased and is now perhaps the largest in the world; tests were also made of the insecticidal value of such plants. Quinine plants were tested as to their suitability for production in Puerto Rico. Studies were made of the cross-pollination of sweetpotato varieties; and 30 selections of corn were grown and seed of crosses returned to the Bureau.

In addition to such specific cooperation with the bureaus of the Department, the Mayaguez station assisted in the work of the bureaus by furnishing physical plant, including land and laboratories, for research needing such facilities in the Tropics. During the year a number of research staff members from the Bureau of Entomology and Plant Quarantine were stationed in Mayaguez, and before the close of the year cooperation was entered into with the Soil Conservation Service, and the representatives of that Service were assigned headquarters at the station.

A number of investigations of special interest to agriculture in Puerto Rico were active during the year. The station concentrated much attention on the introduction of bamboo and its uses on small farms and in the manufacture of furniture, household utensils, and for other purposes. Some 30 species of bamboo have been introduced. As a result of this work, the manufacture of furniture and other household equipment is becoming established in the island. This project was of special local interest and had the support and the cooperation of the Puerto Rico Reconstruction Administration.

Two new sweet corn varieties developed by the station through years of breeding and selection were given further experimental and commercial trials. These varieties appear to have real promise, both for improving the food supply of the island and for possible shipment when markets are available in the United States. Studies were continued to determine the possibility of developing vanilla production. The results are promising. Considerable research was undertaken to assist in the development of truck crops for which Puerto Rican frost-free climate appears to be suitable. In cooperation with the specialists of the Bureau of Animal Industry, work of the station toward a better understanding and control of animal parasites was strengthened. Reports from plantations continue to indicate that acreages of new varieties of sugarcane developed at the station are steadily increasing.

With advice and consultation of personnel from the Soil Conservation Service, several forms of terraces were laid out for study in the control of soil erosion under the heavy rainfall conditions of Puerto Rico. The results were of such interest that the Puerto Rico Reconstruction Administration, before the close of the year, proposed assignment of a works camp to the experiment station to develop a demonstration of erosion control and methods of control cultivation. A more detailed review of the investigations pursued during the year will be given in the annual report of the station for 1936.

Excellent progress in the development and coordination of the research work in Puerto Rico, including the work of the Federal station at Mayaguez, that of the insular government station, and of the bureaus of the Department, is reported.

The publications of the station during the year were Bulletins 37, Parasites and Parasitic Diseases of Horses in Puerto Rico, and 38, Parasites and Parasitic Diseases of Swine in Puerto Rico, both by H. L. Van Volkenberg.

Articles prepared for publication in the station's mimeographed series, Agricultural Notes, were as follows: Notes on the Present Sugarcane-Disease Situation in Puerto Rico, by J. H. Jensen (no. 69); Notes Concerning Internal Parasites of Poultry in Puerto Rico, by Eloise B. Cram (no. 70); and Sea-Island Cotton in Puerto Rico and Its Relation to Production in the Continental United States, by W. H. Jenkins (no. 71).

A set of graphs showing results of studies of rainfall distribution in Puerto Rico was also issued.

Articles prepared for publication in outside journals were as follows: Actividades de la Estacion Experimental del Departamento de Agricultura de Estados Unidos en Mayaguez, by Atherton Lee (Rev. Agr. Puerto Rico, 27 (1936), no. 1, pp. 16–21); and A Method

for Recovering the Strongyle Larvae of the Horse, by H. L. Van Volkenberg (Helminthol. Soc. Wash. Proc., 3 (1936), no. 2, p. 65).

Two notes were prepared and published in Experiment Station Record as follows: Note on Silver Cup Award for Bamboo Project (E. S. R., 74, p. 576); and "News Note" Trip to Santo Domingo (E. S. R., 74, p. 894).

IMPROVED FACILITIES FOR RESEARCH

After a period of unavoidable limitations due to the depression, there was considerable evidence during the year of improvement of equipment and facilities for research, particularly offices for the research staffs and provision for laboratory and controlled experiments. The expenditures for addition to equipment for the stations as a whole during 1936 was $1,781,321 as compared with $1,062,257 in 1935, the lowest in 10 years. Provision for libraries rose from $48,486 in 1935 to $53,999 in 1936. Some of the improvements in station facilities for research were as follows:

The Arkansas Station, partly by the use of labor furnished by the Federal Emergency Relief Administration, completed a two-unit greenhouse, 32 by 107 feet, with a native stone base, semi-iron frame, and connecting passages. The departments of entomology, plant pathology, agronomy, and horticulture are to share in the space in these new units for research.

In Florida, the animal nutrition laboratory at the main station was reconstructed at a cost of about $2,500. A dairy barn and two concrete silos, costing about $5,400, were added to the equipment at the Everglades Experiment Station; a sheep barn, costing about $1,500, at the North Florida Experiment Station; and cattle-feeding and implement sheds, costing about $1,500, at the Citrus Experiment Station.

The Georgia Experiment Station erected an addition to the station building at a cost of about $4,000 and provided two cattle-feeding sheds valued at $300 each. With labor and some material furnished by the Works Progress Administration the station constructed soil plats, separated by concrete walls, to supply uniform conditions for some of the soil projects in progress.

A 38-acre tract, with adequate electric power and water for irrigation available, and within easy driving distance, was transferred to the Hawaii Station for use as a substation.

To replace a former experiment field, the Indiana Station acquired in Knox County a 43-acre farm, with small storage buildings, a peach orchard, and a 7-acre wood lot. The projects under way there include erosion control, fertility trials, pasture-grass studies, crop variety testing, rotations, and experiments with horticultural crops. In Gibson County 45 acres of sandy soil were secured for the Southwestern Indiana Horticultural Farm, and in the northern part of the State a 20-acre tract to constitute the North Indiana Muck Crop Farm. The station leased 20 acres which eventually will be a gift to the station and made a contract to purchase 80 acres adjoining the agronomy farm near LaFayette.

The Iowa Station planned the construction, on its Poultry Husbandry Experiment Farm, of a brooder house, 30 by 136 feet in size,

carefully insulated and provided with an oil-heating unit capable of controlling temperature and humidity and removing impurities from the air. In summer the building may be cooled to some extent by the circulation of air from this unit. The capacity of the brooder house will be approximately 7,000 chicks up to 5 weeks of age.

The Kansas Station erected, on its poultry farm, at a cost of about $2,000, a permanent brooder house, 20 by 100 feet in size, and with a capacity of approximately 3,000 chicks. Under a special State appropriation of $5,025 the former serum plant was improved and equipped for a laboratory for research in animal diseases.

Additions to equipment at the Kentucky Station included a calf barn, a laboratory, and a greenhouse for tobacco research. The building of a wing to the experiment station building for offices, supply rooms, and laboratory space was financed from a P. W. A. grant of $44,000 and a bond issue of $50,000.

A new building program, to be entered upon by the Louisiana University and Station, utilizing the proceeds of a bond issue of $1,500,000, will include, in addition to increased provision for chemical laboratories and general classroom space, an animal industry building, a cold-storage plant, an agricultural building housing the department of forestry and the offices and agencies of the United States Department of Agriculture located at the university, and a physics and mathematics building. The plans include also extensive construction projects for sewers, street widening and pavement, the improvement of the 665 acres of land recently purchased for an addition to the university farm, and similar work undertaken as W. P. A. projects.

For use of the agricultural college and experiment station the University of Maryland began the construction of a set of modern buildings, including a meats laboratory, a judging pavilion, holding pens, a complete set of dairy barns and paddocks, a horse barn, and a machine shed. In connection with these buildings, 212 acres of land adjacent to the grounds of the university were acquired. In addition, a tract of 225 acres, not at the station but readily accessible, was purchased for use as a livestock farm and to furnish facilities for experiments with horses, beef cattle, sheep, and swine.

Funds were provided by the last Mississippi Legislature for a new veterinary science building at the Mississippi College and Station, for use in teaching and research.

The University of Missouri completed and equipped a wing to its home economics building, which practically doubles the space for the home economics department. Two greenhouses were built; one for experiments in plant genetics, equipped with artificial lights for regulating conditions during cloudy weather and short winter days, and the other provided with control of both soil and air temperature for studies on the effect of temperature on the important grasses of the State.

The Nebraska Station completed plans and let a contract for two greenhouse units, each 28 by 100 feet, with appropriate head houses.

Property acquired by the New Jersey College and Station consisted of over 13 acres of land, with an eight-room dwelling, a large office and factory building, and two outbuildings. The office and factory building has available about 30,000 square feet of floor space. With

the aid of emergency agencies the station continued the clearing, draining, grading, and other improvement of land. On a tract of approximately 43 acres about 60,000 feet of drain tile has now been placed.

The New Mexico College of Agriculture completed and equipped, at a cost of over $64,000, a home economics building for use in instruction and research.

A 400-acre tract of land, transferred by the State prison system to the North Carolina Station for the use of its animal husbandry department, will facilitate greatly the work of this department heretofore handicapped by inadequate room for livestock. With the aid of the P. W. A. much of this land was cleared, fenced, and plowed for seeding to pasture. A house suitable for a superintendent's residence was transferred with the land. A well-equipped cattle barn was erected at a cost of approximately $4,000, and the plans call for the construction of a hog barn and a sheep barn. The present animal husbandry farm is to be turned over to the workers in agronomy.

In cooperation with the Bureau of Plant Industry, the Oklahoma Experiment Station completed a gin building and installed machinery operated by an electric motor for ginning foundation seed stocks and cotton grown in plat experiments. This building, a brick and tile structure, contains two gin stands, with space for a third, and a dryer for conditioning the cotton before ginning, as well as laboratories and offices for the cotton research staff.

Pennsylvania State College recently purchased for $5,000 an adjoining farm of approximately 200 acres for use in research and instruction. This enlarged area will supply the needs of the new regional pasture laboratory on land owned by the college or transferred by it to the Bureau of Plant Industry. Plans are under way for building a laboratory and office building, greenhouses, and service buildings, together with an ultimate utilization of a tract of land extending to probably 40 acres. In the establishment of a display garden for the division of ornamental horticulture, a considerable area was set aside for annual flowering plants, and it is intended to include also an extensive rose garden. In cooperation with the Federal Resettlement Administration, plans are under way for the development of a research forest in Stone Valley, between State College and Huntingdon, to serve the station as a field laboratory for forestry work. The area includes approximately 6,000 acres, on which the Resettlement Administration has obtained options.

The South Carolina Station completed, at a cost of about $40,000, a dairy barn, replacing the one destroyed by fire in the spring of 1935. This barn is equipped with modern milking and milk-handling apparatus, and other devices and fixtures. In January 1936, work was begun on the new agricultural building, which, with equipment, will cost about $400,000. This is financed by P. W. A. funds and will house the offices, laboratories, and classrooms of the station, school of agriculture, and extension service. The Pee Dee Branch Station contracted for the purchase of 154 acres of land costing about $5,000, to be used chiefly for work on cotton and tobacco. This station expended about $1,650 for the construction of sheds and fences and repairs to buildings. The Sand Hill Experiment Station expended $1,200 in building a hay shed and repairing and remodeling a resi-

dence. A steer-feeding barn was erected at the Coast Experiment Station.

At the Tennessee Station the Tennessee Valley Authority constructed a laboratory greenhouse for use in fertilizer and other plant-nutrition studies. The station, with P. W. A. funds, completed a cotton and corn research laboratory; with W. P. A. labor it built a small barn for agronomy work, and, at Greenville, improved, at an outlay of about $7,000, the equipment of the erosion station.

Improvements at the Texas Station included a greenhouse for the division of horticulture, a cow shed, and a storage house for work on the curing of meats. At the substations, among the more permanent additions to equipment may be mentioned a house at a field laboratory of the substation at Nacogdoches, and a residence at the substation at Chillicothe.

The Vermont Station, at a cost of about $3,500, erected a barn for livestock-feeding experiments.

The construction of a new laboratory for housing the research in rural electrification and household engineering was begun by the Virginia Station, as a P. W. A. project. This building, planned as a one-story structure, 45 by 133 feet in size, is laid out as a regular laboratory wing of the future agricultural engineering building. This station supplied, also, during the year soil plats with the necessary field houses for the study of run-off and soil erosion, special cages and other means for the investigation of turkey diseases, and equipment specifically devised for use in soil-sterilization research. Near Chatham, in the tobacco-growing section of the State, the Virginia Station began the construction on owned land, at a cost of about $3,200, of a field laboratory for the study of tobacco diseases. The plan called for a single-story structure, with full basement, provided with water, heat, and electric power, and adequately equipped for basic research on soil-borne diseases of tobacco. The main portion of the building will be 26 by 30 feet in size, with an adjoining workroom, 12 by 18 feet, connected with a standard section of greenhouse, 18 by 18 feet.

At the Washington Station a laboratory for research on new products and byproducts from fruits and vegetables was established by the United States Department of Agriculture in cooperation with the station. This laboratory will be under the direction of H. C. Diehl, senior physiologist of the Bureau of Chemistry and Soils and in charge of the frozen-pack laboratory at Seattle; and under the immediate supervision and management of H. H. Mottern, chemist of that Bureau. Otto Johnson, assistant chemist of the station, will devote his entire time to the work of this laboratory.

The Wisconsin Station built a sheep barn for about $18,000, and expended about $4,000 for fencing on its farms.

MAJOR CHANGES IN PERSONNEL

The number of major personnel changes at the experiment stations during the fiscal year 1936 approximated 124, this being an appreciable increase over similar changes occurring during the past several years, due partly to an unusual number of retirements, but largely to increased appointments to the staffs brought about by the Bankhead-Jones Act.

Very few changes were made in directorships. In Oklahoma L. S. Ellis served as acting director during the absence of the director of the station, C. P. Blackwell. Utah reported the selection of Lowry Nelson to serve as director, his appointment being effective in the spring of 1936. H. P. Cooper was appointed director of the South Carolina Station to take effect July 1, 1936.

PUBLICATIONS

The stations issued 770 publications of the regular series during the past year as compared with 864 the previous year. Classified by scientific subjects these publications fall into the following groups: Meteorology, 12; soils and fertilizers, 50; field crops, 78; horticulture, 98; forestry, 5; plant diseases, 53; entomology and zoology, 54; foods and human nutrition, 21; rural-home management, 8; animal production, 80; dairying, 48; diseases of livestock, 29; agricultural engineering, 33; economics and sociology, 117; and annual reports and miscellaneous publications, 84. Classified by major objectives of the work, the publications, exclusive of certain purely regulatory and service publications, may be grouped approximately as follows: Improvement in crop production and products, 378; improvement in animal production and products, 188; and improvement in rural economic and social conditions, 144.

In addition to their regular series of publications, the stations contributed 2,665 articles reporting or based on their work to 100 outside technical or scientific journals, and 34 of the stations contributed or collaborated in 83 articles published in the Journal of Agricultural Research.

The above figures show that whereas the number of publications of the regular series declined from 864 to 770, the number published in outside journals (2,665 as compared with 1,778 the previous year) materially increased during the year.

There is a growing demand for publication of results of the station work in outside technical journals. Some difficulty has been encountered in providing in a satisfactory way for such publication. The matter has been the subject of careful consideration by a special committee of the Association of Land-Grant Colleges and Universities, which, at the last meeting of the association, reported its conclusions as follows:

(1) The question of whether to publish technical papers in journals and proceedings or in bulletins, or both, is a local issue which should be decided by each station, rather than by agreement among all stations.

(2) It is neither possible nor desirable for all stations to pay for space in scientific journals or proceedings, except for overrun in text and illustrations. It is not possible because of legal restrictions in the use of Federal funds and, in some States, in State funds also. It is not desirable because, in the opinion of the committee, it is unsound in principle from the point of view of both the stations and the journals. The committee is of the opinion that the best interests of the stations will be served, especially in their public relations, by publishing technical as well as popular manuscripts in the station series; that it is important to preserve to the editors of journals and proceedings complete independence of judgment in the critical appraisal of manuscripts, and that this principle is likely to become vitiated if the acceptance of subsidies should become general; that it is equally important to preserve to scientific workers in all fields equality of opportunity for publication, and that if a subsidy policy were adopted by a considerable number of stations it would be a handicap to

those stations which lack State funds or which are prevented by State regulations from paying for space.

(3) The agricultural experiment stations are vitally concerned in maintaining the scientific journals and proceedings as auxiliary agencies for reporting the results of research. To this end, the committee suggests that each station give consideration to the following publication policy:

The publication of the final results of all major research projects in the bulletin series of the station.

The publication of progress reports, significant minor phases of the work, and descriptions of research technique, in journals or proceedings, payment to be made only for overrun in text or illustrations, or for special work.

A much more liberal policy in the purchase of reprints than has thus far prevailed, not only because these can be used to advantage, but also because this is a means of compensating, in some measure, for the service rendered to stations by the journals and proceedings.

The Office of Experiment Stations has recently ruled that "the expenditure of Hatch or Purnell funds for printing in a scientific journal, except for the cost of reprints, is not consistent with the provisions of these acts." This ruling applies to the Bankhead-Jones fund also, and the Adams fund cannot be used for printing.

The stations expended for publication during the year $257,024, as compared with $253,926 the previous year. While this was not a large increase it was in significant contrast with the amounts used for this purpose in the past few years.

There was continued and renewed evidence of a growing purpose to make the results of station investigations more widely and readily understood and applied.

SOME RESULTS OF RECENT STATION WORK

The following review of recent station work has been prepared by specialists of the Office of Experiment Stations from current publications of the stations, communications from station directors, and other authoritative sources. It presents a few examples of station work in terms of major research problems and objectives considered to be of special significance at the present time. It is necessarily selective and not a complete summary of all recent accomplishments of the stations as a whole or individually. It is hoped, however, that the review will be found fairly representative and serve to indicate especially that the work of the stations is of value to urban, as well as rural people, and in line with national, as well as local, recovery and adjustment policies.

PLANT PRODUCTION AND PRODUCTS

As would be expected, research relating to plant production and products is extensive and varied and is every year receiving a larger share of the attention and energy of the stations. A few of the great number of examples of research relating to soil fertility, fertilizers, weed control, protection of crops against plant pests and diseases, and more efficient production of better quality crops recently reported by the stations follow.

SOIL FERTILITY AND FERTILIZERS—GENERAL

Maintenance of fertility.—In a series of experiments extending over many years the Oregon Station found that relying on rainfall for moisture and reseeding the crop year after year on the same

soil were unprofitable. Rotation of crops and applications of barnyard manure materially increased yields. The use of irrigation under the continuous-cropping method was not much more profitable than continuous cropping without irrigation. The substantial gains throughout the period of the experiment were made with rotated crops under irrigation, especially with added applications of manure.

Fertilizers alone not enough.—Warning against a tendency among farmers to depend too exclusively on fertilizers in crop production and not enough on other practices which increase crop yields, the Missouri Station says that the proper use of commercial fertilizer is in connection with a good cropping system, preferably one that contains a legume crop such as clover once in 3, 4, or 5 years. Along with this should be the feeding back on the farm of as much of the crops grown as possible. When used in this manner, fertilizer does not injure the soil, further increases the crop yields over those derived from a good crop rotation and the use of manure, and when used in proper amounts and compositions, the profit is markedly increased.

Improving the productivity of muck soils.—The Michigan Station has found that the productive value of muck soils is greatly influenced by soil reaction and moisture conditions and that the soil reaction can effectively and beneficially be controlled by applications of lime to reduce acidity or of sulphur to increase it. The soil-reaction changes, resulting from these treatments, are accompanied by many other changes in the soil affecting its productivity, such as changes in the solubility of lime, phosphorus, potassium, and other soil nutrients.

Maintenance of fertility in irrigated soils.—The New Mexico Station has shown that there has been no important change in the nitrogen content of certain New Mexico soils, clay loams and sandy loams, as a result of 40 years of cropping and irrigation, although the soils are naturally low in nitrogen and have received no nitrogen fertilizer. In fact, the sandy loam has increased slightly in nitrogen, probably as a result of almost continuous cropping with alfalfa. The results of the station's experiments indicate a persistence of fertility under irrigation much beyond expectation and suggest a smaller fertilizer bill for the future in comparison with some humid regions.

Tank culture.—The California Station has further perfected its method of growing plants in tanks containing solutions of the essential plant nutrients, and commercial use is beginning to be made of the method. Potatoes have been grown by the method at the rate of 2,465 bushels per acre. Abnormally tall tobacco plants have been grown under conditions indicating the possibility of complete control of leaf quality. The potential yield of tomatoes from a given area was many times greater in the solution than in soil because of the greater number of plants, their greater height, and the longer growing period. Heating the cultural solution was also found to be of marked benefit. Other plants such as gladioli, sweet peas, cucumbers, and papayas have been grown successfully by the method.

Rapid soil tests.—A method of determining potash deficiency in soils based on growth of mold on soils, devised by the New Jersey Station, has so far given very promising results. Comparisons

between this biological method and a rapid chemical method showed good correlation in most cases, and there are indications that the mold test is fully as reliable. A simple field test for potash in soils has been devised by the Illinois Station.

Rapid tests of soils and plants for available nutrients have been found by the Virginia Truck Station to be very satisfactory in diagnosing nutrient deficiencies and determining the fertilizer requirements for truck crops. Rapid soil tests have been checked by field-plat experiments to determine the amounts of phosphorus and potash necessary for satisfactory growth of certain crops on soils having different levels of availability of these elements. Tests for phosphorus, nitrate nitrogen, soluble nitrogen, potash, magnesium, and calcium made from the extracted sap of vegetable crops have been used successfully for determining the amounts of these elements to be added to the growing crop to produce satisfactory growth. Methods have been perfected with which it is possible to make a complete analysis in less than 1 hour.

Bacteria and fertility.—Certain groups of bacteria, the New York State Station says, are extremely economical and effective conservers of soil fertility. In the early spring and late fall when plant growth is at a standstill and when nitrates tend to accumulate in large amounts, these bacteria may consume large quantities of nitrates and conserve them against loss from leaching for conversion later into food for the higher plants. They also give off carbon dioxide which is highly beneficial to plant growth, particularly in helping to render plant food of the soil available.

Electric sterilization.—Engineers of the Ohio State University have found it possible to control nematode and *Fusarium* wilt organisms and weeds by electric sterilization of the soil. They have found that a temperature of 150° C. will control *Fusarium* wilt organisms and that a temperature of 140° will control nematodes and weeds. A higher temperature is required to kill weed seeds and a lower temperature may be effective for nematodes. (See also p. 175.)

Vinegar as a disinfectant.—The Massachusetts Station reports favorable results with vinegar, one-half pint per square foot of soil, as a cheap and effective substitute for acetic acid and formaldehyde as a soil disinfectant for protection against diseases of plant seedlings. This quantity of vinegar in the soil has had no retarding effect on growth of seedlings of various plants.

Minor constituents.—There is much and convincing evidence that excess or deficiency of certain elements usually occurring in small amounts in the soil, such as magnesium, manganese, copper, boron, and many others may limit the productivity even of soils well supplied with available nitrogen, phosphoric acid, and potash. For example, the North Carolina Station has shown that certain soils of that State are often greatly benefited by applications of substances supplying magnesium, manganese, copper, boron, and other elements usually present in soils in very small amounts. For instance, the bright red color of cotton leaves in sandy areas of the State indicate a deficiency of magnesium and in some instances losses from this trouble amount to 10 or 20 percent of the possible cotton yield. Dolomitic limestone, or other substances containing magnesium, corrects the trouble and greatly improves the soil. The station has also

found that on certain truck crops such as lettuce, beets, and spinach, 25 to 50 pounds of manganese sulphate to the acre mixed with the fertilizers may often mean the difference between success and failure with the crops. A single application of 50 pounds of copper sulphate costing about $3 has been effective for 3 years in making drained swamp soils more productive.

Much reclaimed farm land in eastern North Carolina can be made more productive, according to the North Carolina Station, by applications of copper sulphate. The soils most benefited by such treatment are those high in organic matter, dark brown in color, and strongly acid. On such soils crops show a tendency to be shallow-rooted and unthrifty. The first step in improving them is to apply finely ground limestone to correct acidity. Some time before planting, ordinary finely ground copper sulphate should be applied at the rate of 50 pounds per acre and worked well into the soil. Too frequent applications of the sulphate may prove harmful.

The South Carolina Station, finding a marked deficiency of minor plant-food nutrients in truck soils of that State, sought a corrective for this condition and has recommended treatments that have produced striking results and made a strong appeal to truck farmers (see report for 1934, p. 19), thus affording an example of the results of research being accepted immediately by farmers, and in a short time almost entirely eliminating a major problem in crop production. One farmer found that the elimination of minor plant-food-nutrient deficiency in his soil, when comparable fertilizer and cultural treatments were followed, increased the yield from about 6 to 60 bushels of corn per acre.

For references to minor mineral constituents in nutrition see page 138.

Fertilizers and soil reaction.—The tendency of certain fertilizers, particularly nitrogenous fertilizers and some of the synthetic products, to modify the acidity or alkalinity of the soil, is being studied by a number of the stations. Using data obtained from a study of drainage water from a lysimeter to which certain nitrogenous fertilizers were applied, the Connecticut (State) Station found that sodium nitrate tended to increase the alkalinity of the soil. Under like circumstances ammonium sulphate tended to deplete the basic substances in the soil and thus to increase acidity. Urea and cottonseed meal tended to increase acidity but to a lesser extent than ammonium sulphate. Cropping tended to decrease the soil bases, except aluminum and manganese, and to increase acidity.

Results obtained by the Arkansas Station from the continuous use of 5–8–6 fertilizer at rates of about 400 pounds per acre show very specifically that all fertilizers containing nitrogen as ammonia will cause an increase in soil acidity, whereas fertilizer mixtures in which sodium nitrate is used tend to keep the acidity of the soil unchanged.

The North Carolina Station among others, cooperating with the Department of Agriculture, has shown the advantage of using limestone both in fertilizer mixtures and in direct applications to the soil to correct the tendency of ammonium sulphate and certain of the new synthetic fertilizers to increase the acidity of soils.

Comparison of the effects of calcium and magnesium limestones on acid soils by the Iowa Station showed that the former reacted somewhat more rapidly than the latter. The calcium limestone reduced

acidity more and stimulated a greater production of nitrates in the soil during the first few weeks after the limestones were applied. This advantage of the calcium limestone was apparently overcome by the magnesium limestone rather quickly and after 8 to 12 weeks there was no apparent difference in the effects of the two limestones on any of the chemical or bacteriological characteristics of the soils studied. Neither limestone was superior in its effects on the yields of wheat and clover. It is concluded from these experiments that in agricultural practice either limestone may be used to advantage to correct the acidity of soils, their long-time effects being practically identical.

The value of 100-mesh dolomitic limestone in correcting acidity of soils and fertilizers and in supplying magnesium deficiency in soils has been demonstrated by the West Virginia Station and others.

A small amount of sulphur or acidulated tankage mixed with fertilizers was found by the Arizona Station to benefit plant growth greatly on alkaline soils.

The injurious effect of overliming can be overcome, the West Virginia Station finds, by liberal use of phosphate or by such treatments, as, for example, the use of dolomitic limestone and calcium silicate, that increase the water-soluble phosphoric acid of the soil.

Manure bedding.—In a 3-year rotation of oats and pea hay, rutabagas, silage corn, and timothy-clover hay comparing cow manure made with straw, sawdust, or shavings as bedding, the Rhode Island Station found some advantage in the use of manure prepared with straw as compared with the other materials. However, no detrimental effects to the land have resulted from the use of straw, shavings, or sawdust bedding.

Conserving and increasing organic matter and nitrogen in the soil.—Comparing various crop combinations and rotations, the Kansas Station found continuous corn to be more destructive of nitrogen and carbon in the soil than any other crop or cropping system. Alfalfa and cowpeas appeared to increase the nitrogen supply of the soil, but the latter was more destructive of carbon than the former. Continuous wheat produced about the same effect as the rotations tested. Total crop production over a period of 25 years and total nitrogen of the soil were shown to be highly and positively correlated. Manuring failed to produce significant increases of nitrogen or carbon attributable directly to the manure and not to increased crop residues. The nitrogen of the soil of the plats studied appears to be definitely approaching an equilibrium characteristic of the crop or cropping system employed.

Certain kinds of organic matter, the New Jersey Station finds, furnish food which enable soil micro-organisms to assimilate and thus preserve the nitrogen, particularly the nitrates, of the soil. Carbohydrates (sugar, starches, etc.) in the organic matter supply energy which enables the organisms to transform nitrates that are readily lost to the soil through drainage and other ways into more stable organic formation. Lignin, another common constituent of organic matter, absorbs ammonia which might otherwise be lost and aids in the fixation of protein. The advantage of incorporating manure, composts, and plant residues in the soil is therefore obvious.

Green manuring Everglades peat.—Results of the tests by the Florida Station of the practice of green manuring sawgrass peat

indicate the very probable importance of using such a procedure in the cropping program. The mass of organic material, of which these lands are largely composed, appears to be revivified by the incorporation of a relatively minute amount of fresh organic material that decomposes readily. The availability and possible loss of the nitrogen of the sawgrass peat of the Everglades is intimately related to the need that these lands develop for the incorporation of energy-producing materials such as green manures.

Artificial manure.—The Missouri Station has shown that by applying proper reagents (nitrogen fertilizers, preferably ammonium sulphate) to straw as it leaves the thresher by means of a special attachment, and by spreading the straw in a shallow pile, 4 or 5 feet deep, so that it will catch rainfall, an excellent grade of artificial manure may be produced within a few months. The Michigan Station also has been successful in preparing synthetic manure, which is considered equal or superior to barnyard manure in increasing crop yields.

Organophosphates.—The Nevada Station has developed types of organophosphates which show remarkable ability to penetrate into the deeper layers of the soil and have unusual chemical availability. The station observed that none of the phosphates currently used as fertilizers can penetrate appreciably below the plow line, due to their common fixation in insoluble forms. However, the root systems of orchard trees, and indeed of practically all crops, forage extensively below the plowed layer of soil. It therefore undertook to discover a form of phosphate that would not be fixed in the surface soil but would permeate the deeper soil layers. The station found it possible to produce a highly available type of organic phosphate which escapes, to a remarkable degree, the fixation so common to forms of phosphatic fertilizer now used. The station suggests that preparation and use of such phosphates would furnish a means of utilizing a large part of farm-grown raw materials which now go to waste.

Availability of phosphates.—According to the Ohio Station, response to phosphate additions appears to be greater in an intermediate reaction range of about pH 5.5 to pH 7.0 than at either more acid or more alkaline reactions. This station also has found that the availability of native phosphates in the naturally acid Wooster and Canfield silt loams is notably increased by liming to a reaction around pH 7.5.

Fixation of phosphorus.—Studies by the Virginia Truck Station concerning the effect of organic matter on the fixation and availability of phosphorus have shown that 500 pounds of superphosphate applied to a Norfolk fine sand with 3-percent organic content was more effective than a 1,500-pound application to a similar soil having an organic content of only 1 percent. It was also found that the rate of fixation of phosphorus was markedly affected by the soil reaction, being greater at the higher acidity.

Reducing high soil temperature.—The Arizona Station has shown that soil temperatures between June 15 and September 15 may exceed the point at which normal growth of pecans, citrus, and deciduous fruits, berries, and even cotton may be expected in certain soils of Imperial and San Joaquin Valleys in California, and perhaps farther east, but that it is feasible to control the temperature by several

methods. The best method so far found is a thick, dry mulch of some material which will not heat when irrigated. The next best methods have been frequent but light irrigations and the use of a cowpea cover crop.

INSECT PESTS AND PLANT DISEASES—GENERAL

Black field cricket.—The common black field cricket (*Gryllus assimilis*), a serious pest of field and garden crops, as well as of wearing apparel, curtains, bedding, etc., the South Dakota Station finds can be destroyed effectively in fields or gardens, either in its nymphal or adult stages by poisoning with a sodium fluosilicate poison bran bait. In homes, apartment buildings, stores, hotels, or other buildings, crickets may be destroyed by the use of poisoned baits, or through dusting with certain insecticides such as fresh pyrethrum powder, sodium fluosilicate, or sodium fluoride.

Chinch bug control.—"The chinch bug epidemic of 1934", says the Missouri Station, "was the most severe in Missouri in 30 years." Earlier investigation by the station—

> of chemical barriers and dust furrows enabled us to take advantage of the Government's offer to supply creosote for barriers, with the result that the one and one-fourth million gallons of barrier oil used that year in Missouri saved virtually the entire corn crop from the chinch bug, though drought later seriously reduced the yield. The effectiveness of the chemical barrier in stopping the chinch bugs was one of the most convincing pieces of entomological work the station has done in many years.

Seasonal activities and control of wireworms.—Wireworms move upward and downward in the soil, the Kansas Station finds, in response to unfavorable environmental conditions at the surface. Extreme soil temperatures, above 80° or below 32° F., apparently are unfavorable to the larvae. The larvae, however, can withstand freezing temperatures without apparent injury, but they are injured by high temperatures which dry out the soil. The larvae were found to be below the plow line during November, December, and January. The station therefore concludes that fall plowing as a means of control is of questionable value.

The Maine Station finds repeated thorough cultivation to be a practical control method, whereas fertilizers appear to be of little value for this purpose. A short crop rotation has been used to advantage by the station to prevent reinfestation by wireworms when the land had once been cleared of them. Hay crops or long-standing grain crops are favorable to wireworms and should be omitted as much as possible from the rotation. A resistant green manure such as crimson clover or buckwheat can be used in the rotation with crops susceptible to wireworm injury. Various oil treatments have been attempted without very consistent results. Naphthalene, kainit, magnesium chloride, and magnesium sulphate have been toxic under certain conditions and mercurous chloride, sulphur, and carbon tetrachloride have been toxic in varying degrees under laboratory conditions. Calcium cyanide was found to be effective as a soil fumigant for certain species. Although poisons added to baits for the adults usually act as repellents, clover, cut and placed on the soil, has been an attractive bait for one species (*Agriotes mancus*) of the beetles. An important nematode parasite of *A. mancus* was found.

For other references to crop pests and diseases and their control see pages 24, 28, 29, 31, 32, 35, 40, 41, 42, 43, 44, 45, 61, 64, 70, 71, 77, 79, 82, 84, 175, 178.

WEED CONTROL

Weeds are so threatening to crop production that cooperation among several stations and the Department have been undertaken in research relative to their control. In current work, particular attention is being paid to chemical and cultural methods of control, physiology and anatomy of weed plants, and their life history and growth habits.

Petroleum sprays.—In experiments on the control of dandelions with petroleum sprays made by the Iowa Station, certain high-boiling hydrocarbons contained in the groups sold as distillates and kerosene have shown a remarkably differential action when sprayed on bluegrass lawns at the rate of 200 or 300 gallons per acre. Under favorable conditions dandelions have been slowly but completely killed, while bluegrass sod has been affected only temporarily. The results suggest spraying only the water-white products in cool weather, fall applications appearing to be best.

About 70 percent of the dandelion plants growing on plats of grass kept cut short have been killed by the Illinois Station by one application of 4 cubic centimeters per plant of a furfural-petroleum mixture. Heavier applications were required to kill large mature than small plants. The mixture was also effective in destroying broad-leaved plantain but was less effective on quackgrass and bindweed. Late June and July treatments were more effective than later dates. Lighter grades of petroleum oils were always more toxic than the heavier-grade oils.

Control with sulphuric acid.—Sulphuric acid has been used for a number of years, says the California Station, in controlling annual weeds in grainfields. The station has found that about 95 percent of the mustard and wild radish in grainfields could be controlled by spraying with dilute sulphuric acid, the sprayed fields often producing 50 percent more grain than the unsprayed. In general 10 percent of acid by weight at the rate of 130 gallons per acre has given best results. Under the conditions the total cost of an application has approximated $3 per acre. The use of dilute sulphuric acid has been facilitated by the use of an ejector-mixing device, developed by the station, which eliminates contact of dilute acid with the spray pump and mixing the acid in open containers.

Bindweed control.—Bindweed or wild morning-glory (*Convolvulus arvensis*) continues to be a most serious menace to crop production in many localities in Corn Belt and Western States. To cope effectively with this pest, the Iowa, Kansas, Nebraska, Minnesota, Idaho, and California Stations are cooperating with the Department of Agriculture in a bindweed-research project which considers, among other phases, the use and effects of herbicides, physiological problems, competition with crops, and control by tillage, pasture, and smother crops. These activities are being supplemented at other stations by projects attacking the bindweed.

Wheat yields on bindweed-infested land, the Kansas Station finds, have averaged 24 percent less than on adjacent areas free from this weed, whereas stands were only slightly less. The reduction in yield is considered as due chiefly to reduction in tillering.

A control plan developed from extensive experiments by the South Dakota Station involves smothering the weed by a combination of fallow cultivation and a smother crop of winter rye.

Control of broomsedge.—Broomsedge, an upright growing grass that reproduces only from seed, has been shown by the Tennessee Station to have some value for pasturage, particularly in its tender stage. The station finds that the best control measure is mowing or close grazing by cattle at a proper time to prevent seed formation. Liming also aids in control by stimulating a better growth of white clover, and phosphatic fertilizers are often beneficial.

Leafy spurge.—The Iowa Station has published an extensive report on the characteristics, distribution, and taxonomic relationships of leafy spurge, its flowering and fruiting habits, pollination, seed physiology and reaction to chemicals, and certain characteristics of the root system, leaf, stem, and latex system from research in progress at its field weed laboratory near Hawarden. Such basic information is quite essential in devising measures for the control of this weed, which is a perennial common in certain areas in Iowa where it causes serious damage to crops. Heavy infestations also exist in eastern South Dakota, eastern North Dakota, and southwestern Minnesota.

Quackgrass control.—Practical information has been published by the Michigan Station on the control of quackgrass in infested fields by double plowing, summer fallow, summer plowing, and by special quackgrass cultivators and control of patches by spraying or dusting with chlorates.

Wild onions.—The common wild onion or wild garlic (*Allium* sp.) constitutes a troublesome weed pest that imparts objectionable flavors to the milk and meat of animals feeding on it, is propagated by both bulbs and bulblets, and its difficult to eradicate. The Georgia Station finds that early spring plowing with late fall plowing can be used successfully to eradicate wild onions from cultivated land. Close grazing of pastures by sheep, the station says, will easily and cheaply eradicate wild onions in less than 2 years. The station advises that—

> When it is desired to graze milk cows on pastures that are infested with wild onions they should be removed from the pasture at least 3 of 4 hours before they are milked. This time is usually sufficient to allow all onion flavor to disappear so that the milk is untainted with it. Beef cattle, sheep, and swine that have been eating wild onions should be kept away from them a week or more before being slaughtered to avoid the flavor in their flesh.

FIELD CROPS RESEARCH

Research with field crops at the experiment stations, as in previous years, has been concerned with the varietal, soil-fertility, cultural, harvesting, and storage problems involved in the production and disposal of crops. However, many other problems have recently demanded special attention, such as the place of special crops in land-use schemes, special cultural and varietal practices for drought and soil-conservation conditions, crop conditions peculiar to a regional development, as in the Tennessee Valley, and the country-wide movement toward increased forage and pasture production.

Many of the new as well as the older problems extend beyond the jurisdictions and the personnel and financial resources of a single

station and have best been dealt with as cooperative enterprises among a number of stations and the Department. Excellent examples of such coordinated effort are the extensive cooperative variety and breeding projects with wheat, oats, and barley, carried on by many stations working in cooperation with the Bureau of Plant Industry, and embracing whole regions. In cooperative tobacco investigations, also of importance, interested stations and the Department undertake varietal improvement and adaptation, the solution of problems of crop nutrition, disease control, and curing practice. The recent movement toward increased forage production, aided by the cooperation of the Bureau of Plant Industry and many stations, and dealing with pasture improvement, plants, and utilization, is exemplified in the Northeastern Regional Laboratory for Pasture Improvement, located at the Pennsylvania Station. Established on recommendation of stations in 12 Northeastern States, by the Department of Agriculture under the provisions of the Bankhead-Jones Act, the laboratory serves as a focal point for regional research in pasture improvement; its basic research is coordinated with the research in a number of pasture projects of the cooperating stations under an approved general program.

Soybeans have been given particular attention by interested stations, bureaus of the Department, and trade agencies. A regional laboratory for soybean research with special reference to industrial uses has been set up at the Illinois Station, and involves the cooperation of 12 stations and the Department of Agriculture. Grain storage on the farm, as a research problem, involves seven stations in different regions of the country, working in cooperation with three bureaus of the Department of Agriculture. A comprehensive program of cotton research, looking to the improvement of quality and the strengthening of the position of the crop in world demand and trade, covers most aspects of cotton production, utilization, and marketing, and is being conducted cooperatively by the stations in cotton-producing States and different bureaus of the Department. A noteworthy example of cooperation between station agronomists and other workers, and specialists of the Department, has been the exhaustive survey of better crop plants and animals, sometimes referred to as the survey of superior germ plasm, reported on in detail in the Yearbook of Agriculture, 1936. This cooperative effort has provided a vast deal of information on the status, methods, objectives, and accomplishments in the improvement of the major field crops, including wheat, barley, oats, rice, corn, sorghum, sugarcane, sugar beet, cotton, flax, and tobacco.

In presenting the examples of accomplishments in field crops research in the following pages, especially those with more or less immediate practical application, it is emphasized that repetitions of field experiments during several seasons—because of climatic variations, differences in plant habit and cultural requirements, etc., of the several crops—are essential for valid conclusions and trustworthy recommendations. Consequently, some of the results may appear fragmentary and unrelated, although they fit into the general scheme of crop production. It also is evident that the number of findings reported each year is not in proportion to the relative importance of the crop.

COTTON

Cotton investigations in progress or completed during the year included research concerned with factors affecting field stands such as soil crusts, seed treatments, and seed-borne diseases; disease control; plant foods, their placement, deficiencies, and effects; cover crops and green manures; varietal improvement for various agronomic and technological qualities; and development of one-variety communities.

Effect of soil crust on stand.—During endeavors to overcome the injurious effect of soil crust on cotton seedlings, the Alabama Station has observed that in most cases the percentage and the rate of plants coming up were increased by compacting the soil under the seed. Use of a planting method employing this principle increased the emergence 20 percent. With abundant moisture, compaction of the soil under the seed did not increase materially the percentage of stand.

Delinting cottonseed.—Delinting of cottonseed with sulphuric acid is increasingly practiced to aid germination and reduce disease. The Alabama Station has obtained very satisfactory results with a method for delinting cottonseed, proposed by the Tennessee Station, of using 1 part by volume of concentrated commercial sulphuric acid to 17 parts of seed. This saves about 60 percent of the acid required in other methods proposed. The station finds that concentrated sulphuric acid diluted with 5 parts of water will treat effectively 60 parts by volume of cottonseed. This treatment costs only one-tenth as much as the older immersion method. The Arizona Station, in cooperation with a commercial plant, has developed a continuous delinting, sterilizing, and drying process which appears to be more effective for this purpose and less costly than farm methods currently in use. The acid-delinting machine makes possible the elimination of angular leaf spot, thus lowering the farmer's plant-disease toll, and at the same time insures better germination, thus saving for sale at the oil mill half the quantity of seed formerly thought necessary for planting.

That the use of acid-delinted seed and of certain mercuric compounds has greatly decreased losses from angular leaf spot has also been confirmed by the Mississippi and South Carolina Stations. The latter station finds poor stands due to seedling diseases to be a major cause of losses to cotton farmers, especially in cool, wet seasons; substantial increases in stand and in yields have come from delinting and treatment with organic mercury dusts.

Control of root rot.—Studies made by the Texas Station indicate that cotton root rot (*Phymatotrichum omnivorum*) may be controlled to a large extent by planting Sudan grass, sorghum, oats, wheat, or corn on land infested with the rot. The grass, which most nearly occupies the land throughout the year, was found to be most effective in combating the disease. The station has found that cotton root rot can survive on 14 different winter and spring weeds normally found in fields devoted to continuous cotton or to corn on fallow. Such weeds may therefore act as bridging hosts, enabling the disease to spread to succeeding cotton crops or to summer weeds nearly always present in corn or on fallow fields. The station finds that root rot does most damage on fertile soils which, as a rule, are heavy in texture and alkaline in reaction, such as those of the Blackland

Prairies and the Rio Grande Plains, while soils on which losses due to rot were low were mostly light in texture, deficient or low in phosphorus, potassium, lime, and magnesium, and slightly acid.

Wilt and rust.—The Arkansas and Mississippi Stations have developed several promising strains of cotton resistant to wilt. These stations and the Georgia Station have found that through the use of a wilt-resistant variety and a well-balanced fertilizer supplying plenty of potash, cotton wilt and potash hunger or rust can be controlled. The South Carolina Station observes that the effects of potash deficiency and the benefit from potash fertilizers appear to be most pronounced in dry seasons.

The Tennessee Station reports that the greater number of wilted cotton plants was found on the higher elevations, where the soil was less acid and low in organic content.

Fertilizers.—Experiments by the Alabama Station show that superphosphate and 2-percent ammoniated superphosphate are equally effective sources of phosphorus for cotton soils, both surpassing 4-percent ammoniated superphosphate and precipitated tricalcium phosphate.

The Georgia Station, cooperating with the Department of Agriculture, found that fertilizer placed directly under the seed retarded germination and injured the stand, while placements at the side of and below the seed resulted in better stands and higher yields.

The use of magnesium in cotton fertilizers, the Georgia Station found, increases yields on most soil types in its State. Dolomitic limestone gave better results than calcic limestone. Addition of gypsum to cotton fertilizers free of sulphur also increased yields. Addition of fertilizer materials containing large amounts of soluble sulphates, chlorides, or nitrates, the South Carolina Station found, tends to increase the solubility of soil magnesium and also its loss in the drainage. Dolomitic limestone replacing inert filler in mixed fertilizer markedly decreased the amount of magnesium deficiency and the resultant harmful effect on cotton. As to the effect of magnesium on the cotton plant, itself, this station observed that plants grown in high-magnesium solution have greater top and root growth, longer fibrous and relatively unbranched roots, are delayed in fruiting, but produce fully twice as many bolls as plants grown in low-magnesium solution.

Winter cover and green-manure crops.—Growth response of cotton following a winter cover crop, the South Carolina Station found, is greater after Austrian peas than after rye. Its results emphasize the importance of having a favorable soil reaction for the decomposition of a rye green manure crop. Crops after rye sometimes fail almost completely because of the slow decomposition of the rye material in the soil and the resulting acid condition.

Comparing winter legume green manure and sodium nitrate, the Georgia Station found that green manure of hairy vetch and Austrian winter pea turned under 2 weeks before planting cotton resulted in slightly larger cotton yields than 100 pounds per acre of sodium nitrate applied at planting. Seed cotton yields resulting from application of 200 pounds per acre of nitrate of soda averaged 1,154 pounds versus 1,044 pounds from winter legume green manure. Supplementing the green manure with sodium nitrate increased yields over green manure alone.

Improved varieties.—Varietal improvement in yield, disease resistance, and quality of fiber continues to be an important activity of the southern stations. Wilt-resistant strains developed by the Arkansas and Mississippi Stations and yielding a good quality of fiber have been introduced into their States and seed of good-quality strains developed by the New Mexico Station are being supplied to different cotton-growing communities. Estimates are that about 90 percent of all cotton grown in New Mexico is from seed of Acala improved and distributed by the station.

The activities, aims, and accomplishments in cotton breeding and genetics by the stations in cotton-growing States and the Department of Agriculture, working independently and in cooperation, and by other agencies, have been reviewed in detail in the Yearbook of Agriculture, 1936, pages 657–744.

One-variety communities.—A number of stations cooperating with the Department of Agriculture for some time have been furthering the development of one-variety community production of cotton. The Georgia Station reports that in 1935 there were 108 one-variety cotton communities in the State, mostly in northern Georgia, comprising a total of 16,666 farmer members, planting approximately 250,000 acres and producing about 100,000 bales. The communities have acted as seed centers, and about 51 percent of the cotton grown in north Georgia was of varieties adopted by these communities. The one-variety communities have improved greatly the staple length of cotton in northern Georgia. From 1928 to 1935 the cotton in the Piedmont section, seven-eighths of an inch or shorter, decreased from 76 to 34 percent, and cotton 1 inch or longer increased from 4.5 to 41 percent.

Fiber quality.—In the course of its research on factors underlying quality, the Arizona Station found a correlation between the height of the cotton plant and the length and quality of the fiber. Fibers averaged longer on tall plants but contained a higher percentage of immature fibers. Both length and maturity of lint were depressed under conditions of severe water shortage. Fiber maturity was definitely improved as the spacing between plants in the row increased from 6 to 30 inches, while, except in the closest spacing, the reverse held for fiber length. The New Mexico Station also reported progress in securing greater uniformity in length of lint as a result of its study of factors which determine quality.

Mechanical devices, termed fibrographs, developed by the Tennessee Station in its quest for improved staple, enable the research worker to measure rapidly and accurately the lengths of fibers on ginned lint as well as on single seeds.

CORN

Improvement.—During the last 25 years many stations, proceeding either alone or in cooperation with the Department of Agriculture and other stations, have sought to improve established varieties or create new varieties or strains of corn by inbreeding and subsequent combination of selected inbreds by hybridization. The progress of these activities has so advanced that a high proportion of the crop in many areas is derived from hybrid seed developed by the stations or by seed growers following their guidance.

From a study of corn hybrids, developed by the Minnesota Station, cooperating with the Bureau of Plant Industry of the Department and other stations, it seems evident to the Minnesota Station—

> that the use of hybrids offers opportunity for growers to produce not only higher yielding corn, but also corn that excels in other important characters, such as standing ability, disease resistance, and adaptability to different regions in the State. In the last few years the demand for hybrid seed corn has shown a steady, rapid increase. * * * On the basis of the present-day trend of increase, it seems logical to estimate that 10 years hence 50 percent or even more of the present corn acreage in Minnesota will be planted with hybrid seed corn.

This station has recently distributed a number of field corn, sweet corn, and popcorn crosses of merit.

The Connecticut (State) Station, which has taken a leading part in seeking to improve corn by inbreeding, has developed many valuable strains, including Red Green, Burr-Leaming, and Spancross C_2 and P. 39.

The Illinois, Iowa, Indiana, Missouri, Nebraska, New York (Cornell), and Ohio Stations, among others, also have developed and tested a number of high-yielding hybrid corns.

The Iowa corn-yield test, an annual enterprise conducted by the Iowa Station in cooperation with the Department of Agriculture and a growers' association, gives much attention to the relative merit of new hybrid corns. In the 1935 test the regular and experimental corn hybrids, considered as a group, outyielded the open-pollinated classes and showed more lodging resistance. The later maturing strains, i. e., with higher moisture content, generally had a greater percentage of damaged seed than the earlier strains. As in the past, hybrid entries performed relatively better than open-pollinated entries in fields where yield was reduced by unfavorable climatic conditions. In the Iowa program of certification of hybrid corn, attempts are being made to teach the grower the proper production method and to acquaint the buyer of hybrid seed with the desirability of using only seed with a known pedigree and performance record.

The performance of the outstanding inbred lines of corn, developed as a result of the inbreeding programs of the stations working independently and in cooperation with the Department, has been summarized in the Yearbook of Agriculture, 1936, pages 504–522, which also lists the corn hybrids developed under similar conditions and distributed for commercial production.

Insect-resistant corn.—The possibility of producing corn hybrids that are outstanding in yield and quality of grain in years when chinch bugs are not present, and that are also highly resistant to damage from second-brood chinch bug attack, thus being of great value in years of serious outbreaks, has been shown by the Illinois Station cooperating with the Illinois State Natural History Survey and the Department of Agriculture. It has also been possible to develop several strains of corn that are markedly resistant to root worms and some other insects.

Varieties of corn from breeders in the Coastal Plain have been found by the Georgia Station to be more resistant to weevil injury than corns produced farther north.

The Michigan Station, among others, has had considerable success in developing strains of corn resistant to the European corn borer.

Maize Amargo, a low-yielding South American corn unsuited to Michigan, but distinctly resistant to the European corn borer, has been crossed with better strains of dent corn to produce a hybrid of distinctly borer-resistant quality and with characteristics of commercial value.

Field observations by the Virginia Truck Station on the life history of the European corn borer indicate that it has at least a partial third generation on the Eastern Shore of Virginia. It finds that the potato serves as the host for the first generation of borers. Corn planted June 1 and 10 has had nearly twice as heavy infestation per stalk as corn planted May 14 or June 27.

Drought-resistant corns.—In a method to appraise the drought-resistant qualities of inbred lines, hybrids, and open-pollinated varieties of corn, developed by the Kansas Station cooperating with the Department of Agriculture (B. P. I.), 14-day-old seedlings are placed in a heat chamber and subjected to a temperature of 140° F. and a relative humidity of 30 percent for 6½ hours. Given an opportunity for recovery under favorable conditions, the various strains exhibit injury ranging from practically none to complete killing. Essentially the same order of relative resistance has been obtained for the seedlings as has been noted for the plants in the field.

Relation between stand and yield.—That reduction in corn yield due to poor stands may be lessened by use of seed with high germination, treatment with an organic mercury dust, and proper selection of planter plates, has been established by the Minnesota Station. It also has shown the superiority of hybrids to farm varieties in average stands.

Injured seed.—Seed-coat injuries at the crown of corn kernels, as often occur in rough ears, the Illinois Station reports, cause lower yields, even though the seed coat is only punctured, due to reductions in stand and in vigor of growing plants. Slight injury on the sides of kernels where horny endosperm only was exposed did not result seriously. Seed with injured seed coats, when treated with ethyl mercury phosphate, produced results nearly equal to those from uninjured seed. The advantages of a type of corn with rather smooth indentation and higher proportion of horny endosperm in better stands and yields and quality of grain are evident.

Chlorosis.—Chlorosis, or white bud, of corn has been shown by the Florida Station to result from malnutrition and to be corrected by applying zinc sulphate at the rate of 20 pounds per acre in a complete fertilizer or by stable manure and chicken manure when applied at reasonable rates in the row. Leafmold from a mixed stand of pines and hardwoods has been effective when broadcasted at the rate of 5,000 pounds per acre. Returning vegetation from weed fallow to the soil has very materially reduced the amount of white bud on an otherwise very severely affected field.

Factors affecting smut.—The Minnesota Station found that slashing and detasseling (or topping) markedly increased smut severity when practiced on corn at an intermediate stage of rapid development, but was ineffective on more mature or less mature plants. Simulating the spiral-loosening effect of twisting in the wind by rolling the leaf spirals between the hands during or just after a rain increased the severity of smut in plants between 12 inches high and

the early boot stage. In general, smut was more destructive to later than to early plantings.

WHEAT

Improved varieties.—Examples of new and promising wheat varieties are Komar, a rust-resistant hard red spring wheat developed by the Colorado Station; Hymar, a low-gluten, smut-resistant, and productive white club wheat from the Washington Station; and Relief, a hard red winter wheat resistant to many forms of covered smuts and with good yield, winter-hardiness, and quality, selected from a cross by the Utah Station. These three wheats and Thatcher wheat were developed in cooperation with the Department of Agriculture. Thatcher, a hard red spring wheat of the Minnesota Station, slightly earlier and with a shorter and more compact spike than Marquis, combines resistance to stem rust from heading to maturity with immunity from several forms of rust in both seedling and mature plant stages. It has been outstanding in yield in both normal and severe rust years, and has equaled or surpassed Marquis and Ceres in milling and baking qualities.

Canawa, a smooth soft red winter wheat with drooping medium-sized spikes and purplish stiff straw showing very little tendency to lodge, is a new variety derived by the West Virginia Station as a pure-line selection from Canada Hybrid. In yields it approximates the productive Fulhio; in cooperative tests with farmers, Canawa significantly outyielded wheats commonly grown. It has satisfactory milling qualities and its flour seems more suitable for pastries and biscuits, yet may give satisfactory results for bread, particularly if blended with stronger flours.

An extremely early variety of wheat, originated by the Missouri Station, and ready for release, is described as a much more efficient nurse crop than other wheat varieties because of its quick maturity and light straw growth and because it lengthens the immediate pasture season of legumes or grasses sown in it.

Early maturing wheat strains, which can escape hot, damaging, midsummer winds, have been produced by the Kansas Station, cooperating with the Department of Agriculture, by crossing early spring Canadian and Australian wheats with the widely grown hardy winter Kanred wheat.

Commercial varieties developed or introduced and first distributed by the stations working alone or in cooperation with the Department, as well as promising new strains, and current work and objectives in wheat-breeding research were reviewed in the Yearbook of Agriculture, 1936, pages 207–302. Other features of recent work of the stations with cereals and their utilization were reviewed by the Chief of the Office of Experiment Stations (Cereal Chem. 13:332–345. May 1936).

Shriveled lightweight seed.—The Montana and North Dakota Stations have found that shriveled lightweight wheat resulting from drought and rust can be planted successfully. Practical suggestions for using such wheat for seed, based on germination, greenhouse, and treatment tests by the North Dakota Station, include the use of the plumpest and heaviest seed available of the desired variety; fanning

and grading to secure the plumpest and best kernels; germination tests; dusting for disease control; and planting at a moderate rate and depth in a good seedbed.

Irrigation.—The highest yields of grain and straw of Baart wheat were obtained by the Arizona Station, in cooperation with the Department of Agriculture, in irrigation tests in the Salt River Valley, from applying 3 inches of water before planting, 3 inches at jointing, 6 inches at heading, and 6 inches at the soft-dough stage. This treatment was most satisfactory in producing plant characters correlated with yield, and also supplied enough moisture after heading to insure good, large, plump kernels.

Soil moisture and winter wheat.—Endeavoring to acquaint farmers with methods of determining at seeding time their chances of obtaining a paying crop of winter wheat and of ascertaining relatively early in the spring whether or not the crop should be abandoned, the Kansas Station reports from its experiments in western Kansas, in cooperation with the Department of Agriculture (B. P. I.), that the depth to which the soil is wet at seeding time is a reliable measure of the available soil moisture and has borne a very close relationship to the yields obtained. This depth can easily be ascertained with a spade or a post-hole digger. Sandy soils must be wet to a greater depth than heavier soils to carry the same amount of water. With comparatively heavy soils wet to a depth of 3 feet a good yield is fairly well assured, and only adverse conditions during the growth of the crop may cause low yields or failure. When the initial soil moisture is deficient and the precipitation is low to April 1, abandonment of the crop and conservation of water in a summer fallow for a future crop probably will pay far better than allowing the water to be wasted by the poor crop and weeds.

Winter injury.—That the ability of different varieties of wheat to withstand soil heaving, the chief cause of winter injury in Ohio, is positively related both with breaking strength and extensibility of the roots, has been determined by the Ohio Station. Its rather extensive studies indicate that certain root measurements vary markedly with variety and with the resistance of the variety to cold and to heaving injury. No one characteristic of the roots alone is an entirely satisfactory measure of ability to resist heaving. The combination of resistant variety and favorable fall environment, both as regards soil and climate, is held essential to reduction of injury from heaving to a practical minimum.

Fertilizers.—Prolonged experiments, covering about a half century, have shown the Missouri Station that very heavy applications of commercial fertilizer with wheat continuous or with a crop rotation have maintained yields as well as heavy applications of farm manure, and also that such applications of fertilizer are in no way injurious to the soil.

Varietal differences in response of wheat to different levels of soil fertility were observed by the Ohio Station, which noted that none of 11 varieties used was definitely superior at only high or only low levels, although the findings did not preclude the existence of such wheats.

Spring applications of soluble nitrogen fertilizer on wheat, the Michigan Station finds, have not given consistent increases in yields on heavy soils.

Highly favorable results have been obtained by the Tennessee Station with calcium metaphosphate, a new product containing 64 percent of phosphoric acid, when used in comparison with common superphosphate for winter wheat.

Control of pests.—The Missouri Station has shown that the Hessian fly can be controlled effectively by plowing under infested stubble, destroying all early volunteer wheat, and delaying planting of wheat in the fall until the fly-free date for the particular community. The wide use of this system has resulted in large savings to Missouri wheat growers.

Cutting wheat slightly before the dead-ripe stage has been found by the Ohio Station to avoid a considerable portion of the lodging caused in eastern Ohio by the black wheat-stem sawfly, *Trachelus tabidus*.

The California Station has successfully checked the ravages of wheat rust by airplane dusting with sulphur at the rate of 25 pounds per acre in two applications with a 10-day interval.

Quality.—Bald Rock and American Banner wheats, the Michigan Station found, may stand for at least 3 weeks after the normal binder harvest date without serious sacrifice of yield from this cause. Delay in harvest apparently increased the strength of gluten and size of loaf, but not protein content. If these wheats are harvested with a combine, it seems desirable to delay harvest until about 1 week after the grain is ready to cut with the binder.

Studying the effect of moisture and temperature at harvest time on wheat quality, the Kansas Station observed that the sugar content and diastatic activity were not influenced unless the moisture content was sufficient to start germination. Wheat cut with 29 percent moisture was not lowered in test weight, which was depressed slightly at higher moisture contents. Drying the wheat cut with a high moisture content slowly and at a low temperature increased diastatic activity but not the sugar content.

Climate, particularly precipitation, appears to be the factor exerting the greatest influence on strength and quality of soft winter wheat, according to experiments in cooperation with the Indiana and Michigan Stations, reported by the Ohio Station. Temperature apparently acts only as a modifying factor on precipitation. Soil exerted almost as much influence as climate on the protein content of wheat. The supply of available soil nutrients appeared to be the most important soil factor influencing the amount of protein. Nitrogen increased and phosphorus decreased protein content, while potassium was intermediate in effect. Soil reaction also was found to affect wheat strength. In general, the station concludes that "it is through the use of varieties of suitable strength characteristics and through the use of fertilizer treatment and farm practices giving a suitable nutrient supply that the greatest promise exists for regulating the strength of the wheat reaching the trade" to the advantage of the grower, the miller, and the consuming public.

The copper content of wheat grown in different localities of Utah was found by the Utah Station to average 8.8 parts per million, compared with barley, 7.8 parts per million; and oats, 7.4 parts per million. Sixteen varieties of wheat grown on the same soil ranged from 5.6 to 16.7 parts per million of copper, averaging 9.7. No correlation was found between the copper content of the grain and the

producing soil. Variety evidently is the main factor determining the copper content of Utah-grown wheats.

In studies of the relation of color of flour to market value and utility, the Indiana Station observed that carotenoid pigmentation may be useful to the breeders of improved wheats for milling purposes since such pigmentation appears to be a heritable varietal character.

Methods of determining the quality of wheat have been given continued attention by the Indiana, Kansas, Ohio, and other stations, current emphasis being on the wheat meal fermentation time test and its advantages and limitations. The Kansas Station also points out the merits of dough curves made on the Swanson-Working recording dough mixer as criteria of wheat quality.

OATS

Improved varieties.—Columbia oats, originated by the Missouri Station and distributed to growers in 1927, is currently estimated to occupy 1,500,000 acres. This extremely early variety is much more favorable than the older late varieties for the growth of legumes and grasses sown therein, and because of its good yields it replaces considerable corn on medium land.

Other recent advances include high-yielding strains of Red Rustproof oats and selections from Markton × Red Rustproof, developed by the Georgia Station; a higly smut-resistant hybrid from Markton × Fulghum by the Kansas Station; and crosses between the rust-resistant Victoria from South America and various Texas oats, which possess both adaptation and rust resistance, made by the Texas Station, each of these activities being in cooperation with the Department of Agriculture.

Accomplishments of the stations, working independently or in cooperation with the Department in varietal improvement and genetics research with oats were reviewed in the Yearbook of Agriculture, 1936, pages 381–408.

Production practices.—Practices favoring the production of a good crop of oats, reported from results of Missouri Station research, include the early planting of an early productive variety, as Columbia, Fulghum, or Burt oats; drilling of seed treated for smut on suitably prepared land; and the moderate use of fertilizer.

The Colorado Station, from its cooperative experiments with the Department, also has made varietal, cultural, and irrigation recommendations for the crop. It indicates Markton, Colorado 37, and Kanota oats for the varied irrigated conditions and Brunker and Kanota oats for dry land. In similar cooperation, the Utah Station finds Markton desirable in its State, because of high yields, immunity from covered smut, and resistance to loose smut.

BARLEY

Malting and brewing.—Demands of the trade for dependable sources of high-quality barley for brewing purposes have given impetus to extensive research with barley. The Wisconsin Station, cooperating with other stations and the Department of Agriculture, has been active in a coordinated program for barley improvement and research into malting quality. Among other findings it reports

that comparison of five varieties grown in eight States in the malting-barley area and of samples of three varieties grown by farmers in important Wisconsin barley areas, showed Oderbrucker to yield somewhat better quality of malts over the entire range of growing conditions than did any other variety. The varieties with the highest malting quality are reported to be deficient in yield and disease resistance, whereas the more productive barleys are less suitable in malting quality.

The New Jersey Station reports a new winter barley which appears to be of merit for malting and brewing purposes. This barley, if proved as productive as expected and planted early, also should make excellent fall pasture and mature grain in early June of the following spring. It would thus be a useful crop in rotations for potato farms.

Feed barleys.—Missouri Early Beardless barley, originated by the Missouri Station and distributed to growers in 1933, was grown on 600,000 acres, grazed or harvested in 1936. Maturing ahead of drought, chinch bugs, and grasshoppers, it meets a grave need for feed grain when corn fails. It gives high yields of both grain and pasturage, is a superior nurse crop for spring-sown legumes and grasses, is an excellent substitute for corn on medium land, and protects soils from erosion resulting from prolonged continuous culture of corn.

Nobarb, a new smooth-awned winter barley of good quality and high yield, derived from a cross, Tennessee Winter × Velvet, has been developed and released by the Maryland Station.

Flynn barley, a smooth-awn six-row barley, originated by the Department of Agriculture (B. P. I.) and the Minnesota Station, has been approved by the Kansas Station for distribution to growers. This barley matures early and gives high yields and test weight of grain in Kansas.

Trebi barley, the highest yielder in extensive variety tests at the Utah Station, in cooperation with the Department of Agriculture (B. P. I.), has shown its superior yielding ability in different parts of the State. It appears undesirable currently to grow other varities on irrigated lands where barley is grown for feed.

Accomplishments of the stations in barley improvement, working separately or in cooperation with the Department, were detailed in the Yearbook of Agriculture, 1936, pages 303–346.

RICE

The Arkansas, Louisiana, Texas, and California Stations continued in cooperation with the Department of Agriculture to seek solution for the varietal, cultural, irrigation, fertility, and disease and insect-pest problems involved in rice production. Results and objectives in breeding work with rice by these stations, working alone or cooperatively with the Department (B. P. I.), were detailed in the Yearbook of Agriculture, 1936, pages 415–454.

Toxicity of arsenic on flooded soils.—The effect on the yield of rice of applications of varying amounts of calcium arsenate has been studied by the Louisiana Station, which found that the toxic effect is governed largely by the soil type. On the lighter soils rice was seriously affected by 50 pounds per acre of calcium arsenate, while on

the heavier soils 150 pounds was not injurious. Indications were that it is the reduced arsenic compounds, arsenites, etc., that are particularly toxic to rice under flooded conditions.

FLAX

The stations in Northern and Northwestern States, cooperating with the Department of Agriculture (B. P. I.), have been giving increasing attention in recent years to the production and improvement of seed flax. Their accomplishments and current objectives in the improvement of the crop for both seed and fiber were reviewed in the Yearbook of Agriculture, 1936, pages 745–784.

Flaxseed production.—Practical information, largely gained in cooperation with the North Dakota Station, has been published by the Department on flaxseed production in the North Central States, including varieties, cultural methods, and field practices, rotations, weed control, growing flax and wheat as a mixed crop, and flax under irrigation, diseases of flax, cleaning and storing seed, and the marketing and utilization of the seed crop.

An Iowa crop.—Seed flax is considered by the Iowa Station as well suited to Corn Belt rotations, an excellent nurse crop, and usually more profitable per acre than small grains with similar cultural requirements. Production practices recommended from results of its experiments and experience include early April planting of 3 pecks drilled or 4 pecks broadcast of dust-fungicide treated seed of such disease-resistant varieties as Red Wing and Bison on a solid weed-free seedbed, preferably on a heavy soil, and harvesting when the bolls are ripe and the stems are yellow.

POTATOES

New varieties.—As a part of the national potato-breeding program a number of stations have continued to cooperate with the Department of Agriculture in securing additional information on the adaptation and performance of Katahdin, Chippewa, Houma, and Golden potatoes, all new varieties. In Michigan, North Dakota, Oregon, and Idaho, Katahdin has shown ability to produce a good crop of tubers of desirable shape under relatively adverse conditions. Indications are that it will partly replace standard varieties in certain sections of Michigan, Iowa, New Jersey, Oregon, northern Idaho, and the higher altitudes of Colorado. The Michigan Station has outlined special recommendations for growing Katahdin which has produced table stock of good market quality and developed tubers of good type under hot dry conditions. Reports from North Dakota, Minnesota, Michigan, Iowa, New Jersey, Florida, and Louisiana indicate that Chippewa has a wide range of adaptability. Golden, a late-maturing yellow-fleshed potato, produces large yields of medium-sized, roundish tubers with rather shallow eyes, and ranks high in cooking quality, but seems more limited in adaptation than the other two varieties, being particularly suited to northern Maine.

Warba, originated by the Minnesota Station from a cross between Irish Cobbler and Triumph, and subjected to extensive tests in Minnesota, has shown marked resistance to mosaic, matures early, and is very productive. Growers in New Jersey and on the Eastern Shore of Virginia also have obtained successful results with Warba.

Certified seed.—Ability to maintain a high-grade stock of certified seed potatoes over a long period of years by growing the seed potatoes in a separate seed plat from which all weak and abnormal plants are removed before harvest has been demonstrated by the New York State Station in a cooperative experiment during 9 years with a grower of certified seed potatoes in northern New York. The content of virus diseases declined from 2.6 to 0.4 percent during the period.

Fertilizer.—Profitable responses of potatoes to phosphorus have been reported by several stations. Phosphorus applications used in growing potatoes, as Montana Station tests show, have resulted in better maturity and handling qualities, better netting, improvement in type, and an increase in percentage of better shaped potatoes, resulting in heavier yields of no. 1 potatoes. Phosphatic fertilizer, the Missouri Station finds, is needed on most soils of Missouri for increasing the potato yields. In its experiments the best yields were produced where a complete fertilizer high in phosphorus was used, together with manure and green manure. For the average farm crop, where potatoes usually are grown in a fertile soil, manure plus 300 pounds of superphosphate will usually result in the most economical yields.

In 5 years' experiments conducted cooperatively by the New Jersey Station and the Department of Agriculture (B. P. I.), the largest potato yields were made where the fertilizer was applied at each side of the seed piece on the same or a slightly lower plane. Cultural and fertilizer recommendations of the Louisiana Station, from its prolonged experiments, include the use of 1-ounce sets for general planting and 1.5-ounce for very early planting, spaced 14 inches apart in the row and covered 4 inches deep, and application of 800 pounds per acre of 4–8–4 or 4–12–4 fertilizer on a 3.5-foot row basis. Its tests suggest top-dressing within 2 weeks after planting with 160 pounds of ammonium sulphate per acre where added nitrogen is profitable, but where added nitrogen is beneficial and growers do not wish to top-dress, all the nitrogen may be applied at planting.

Green manures.—Potato yields in ordinary farm rotations on the silt loam at the Ohio Station have not been satisfactory with chemical fertilizers alone. However, manure applications have resulted in somewhat better yields, probably due in part to increased soil aeration. Corn as a green manure has provided more organic matter to plow under and has resulted in larger potato yields than has soybeans or sweetclover. No serious practical problems have arisen from the nitrogen deficiency resulting from turning under much low-nitrogen organic matter nor were they encountered in either plowing or disking down corn. The nitrogen needs of potatoes were met by including from 40 to 80 pounds of nitrogen per acre in the fertilizer.

Potato yields in the spring from an area where soybeans or sorghum alone or together in mixture served as a soil-improving crop were practically double those where vegetable crops were grown continuously in rotation experiments by the Virginia Truck Station. Addition of peat for organic matter also has given marked yield increases.

Growing on muck soil.—The Ohio Station finds that muck apparently is the best soil in Ohio for potatoes, although frosts may be serious on muck soils. In its extensive experiments, Irish Cobbler has returned good yields from May 20 to 25 plantings and still higher yields from earlier plantings in seasons free from June frosts. The muck-grown tubers have been satisfactory as seed for the early crop in southern Ohio. Some production practices indicated by the tests were potash fertilizer alone to supply 270 pounds of potash per acre, or 750 pounds of a 0–9–36 fertilizer; seed free from *Rhizoctonia* or treated properly; planting 3 inches deep; shallow covering at planting; and weekly spraying during rapid growth to control leafhoppers and flea beetles.

Seed.—The bud ends of seed potatoes that have sprouts from one-fourth to one-half inch long, the New York State Station finds, have given substantially greater yields than the stem ends of the same tubers. Where the tubers were cut before sprouting, however, little or no difference in yields has resulted. These results, however, do not appear to warrant any material change in cutting and planting practices currently used by New York potato growers. This station also finds that treating tubers and seed pieces of Irish Cobbler and Green Mountain potatoes with yellow oxide of mercury (1 pound to 15 gallons of water) delays emergence, which has affected the growth of Green Mountain but not the ultimate growth of Irish Cobbler plants. Treatment increased the yield from uncut Irish Cobbler seed, but did not affect the growth of Green Mountain potatoes. Treating seed pieces either at the time of cutting or planting may result in decreased yields.

Virus diseases.—Researchers at many stations working independently or in cooperation with the Department of Agriculture and other stations continued to contend with potato disorders, particularly the virus diseases. The scope of this work is shown by the Maine Station, which has listed 26 distinct virus diseases of potatoes and has indications that there are still others.

Its investigations on the serious yellow dwarf disease of potatoes have shown the New York (Cornell) Station that the causal virus is harbored by medium red clover. Since the virus is carried to healthy potatoes by the clover leafhopper, this observation has an important bearing on control measures and helps to explain how the disease is carried over winter and recurs on the same farms year after year, even though new and healthy sources of seed potatoes are planted. This station also finds that other virus diseases, e. g., necrosis and leaf roll, may be transmitted through the true seed of potatoes, a fact of special importance in selecting foundation stock for breeding purposes.

Strains of potatoes derived from Katahdin have been found by the Washington Station to be highly resistant to infection by the vein-banding virus.

Studies by the Vermont Station showed that either slight or severe infection of potatoes by mosaic disease reduced their growth efficiency.

Blight-resistant potatoes.—The Maine Station, cooperating with the Department, has succeeded in obtaining several strains of potatoes resistant to late blight, a disease estimated to cause a loss of

9,000,000 bushels of potatoes annually in the United States. A selection from a cross between two susceptible varieties was only slightly injured in the blight epidemic of 1932, although not sprayed with bordeaux mixture, yet the check potatoes in the same plat were killed by blight.

Scab.—From studies of the effect of irrigated crop rotations upon potato scab, the Nebraska Station concludes that for practical purposes short rotations and rotations where beets immediately precede potatoes are, in general, undesirable, and that the longer rotations with alfalfa preceding potatoes are desirable for both high yields and less scab. Manurial treatments are not desirable from the viewpoint of scab, but are justifiable in short rotations because of the large increase in yield of no. 1 size tubers.

Application of sulphur in the furrow has provided the Texas Station with effective control of potato scab. Attacking the problem from another angle, the New Jersey Station has shown that the common soil fungus, *Trichoderma lignorum*, produces a diffusible substance that is extremely toxic to the scab organism, *Actinomyces scabies*, and suggests a possible biological control of potato scab.

Flea beetle control.—Spraying potatoes five times during the growing season with a calcium arsenate-bordeaux mixture has proved satisfactory, in experiments by the Virginia Truck Station, for the control of potato flea beetle. The practice resulted in increases of 45 to 80 percent in yield of prime potatoes. Spraying has consistently given better results than dusting.

Effect of apples on stored potatoes.—Apples produce a volatile substance affecting the growth of potatoes, the Kansas Station finds. The sprouting of potatoes in storage can be practically stopped and the tubers kept in a well-preserved condition by supplying a sufficient concentration of the growth-inhibiting gas, which does not seem to injure potatoes to be planted. The total sugar content of the tubers, however, is increased, giving them a sweet flavor. Storing potatoes and apples together or in adjacent bins appears to accomplish the desired results.

Sorter and washer.—An economical and convenient potato sorter, which can be built readily on the farm at a cost of $20 to $25, has been developed by the Washington Station. A practical washer for cleaning potatoes grown in sticky soils and harvested under bad weather conditions was also developed. The washed potatoes are cleaned thoroughly and put in attractive condition for the market. For studies of the cost of production of potatoes see page 154.

For studies of cooking quality see page 125.

SWEETPOTATOES

Propagation.—A method of slip propagation of seed potatoes, devised by the Connecticut (State) Station, which provides an effective means of control of the most serious diseases of sweetpotatoes, is being used successfully by Connecticut farmers. Cuttings taken from healthy vines July 25 and planted immediately have taken root readily and by October 10 have produced sweetpotatoes large enough to be stored for use as seed the following spring. The Delaware Station also finds the use of slipping effective in quickly eliminating

sweetpotato diseases. In practicing slipping, it advises that the seed should be planted on a well-prepared field on which sweetpotatoes have not been recently grown, so that reinfection with wilt will not take place quickly. Care should be taken to cut slips from early plants showing no wilt or yellowing.

In comparing the effects of different temperatures in the bedding of sweetpotatoes, the Oklahoma Station's results favor a temperature of 85° F. Rotting of the bedded potatoes, particularly those that were cut in half, has been less at 85° than at other temperatures and the slips were of a more desirable type.

Control of black rot.—Effective control of black rot has been secured by the Mississippi Station by dipping sweetpotato plants, before packing for shipment, in a 20–20–50 bordeaux mixture or in a 25-percent copper-lime dust. There is evidence that this treatment will delay infection from infested soil to an extent that may make its use practicable when clean plants are put on land known or suspected to harbor the disease.

Yield and shape of the Puerto Rico sweetpotato.—That fertilizers high in potash and relatively low in nitrogen return the highest yields has been observed by the Virginia Truck Station, which also reports that potash fertilizers tend to produce chunkier roots.

Curing and storing.—The keeping of sweetpotatoes in storage, the Louisiana Station finds, differs little as to amount of shrinkage or presence of rot, whether or not artificial heat is provided. In the commercially important Sunset district, large quantities of sweetpotatoes are stored in large warehouselike buildings and the roots themselves seem to furnish enough warmth during cold spells to render artificial heating unnecessary. Most of the crop is dug in October when it is comparatively warm and usually dry.

JERUSALEM-ARTICHOKE

During the past decade, the Jerusalem-artichoke has been considered more and more as a possible source of raw material for the manufacture of certain plant products. From its extensive varietal and cultural experiments in cooperation with the Illinois, Minnesota, and Oregon Stations, and also near Washington, D. C., and Cheyenne, Wyo., the Department of Agriculture (B. P. I.) has made both popular and technical reports on the adaptation of the crop in the United States, varieties, cultural methods, and limitations and difficulties in growing and handling Jerusalem-artichokes. The cultural recommendations include the use of only high-yielding strains of acceptable color and shape; sound, disease-free seed tubers; early spring planting of 2-ounce, preferably whole, seed pieces 2 feet apart in 3-foot rows (in Oregon, 3 to 4 feet apart in 5- to 6-foot rows); covering 4 inches deep (5 inches in high dry regions); and leaving the tops undisturbed until killed by frost.

TOBACCO

Tobacco, a crop of great commercial importance, has long been studied intensively by specialists of the stations and the Department of Agriculture, working both independently and in cooperation. Several outstanding results from such activities in breeding tobacco

for various quality characters and resistance to different plant diseases have been described in the Yearbook of Agriculture, 1936, pages 785–830. To cite an example of regional cooperation in research with this crop, the Virginia, North Carolina, South Carolina, and Georgia Stations and the Department of Agriculture (B. P. I.) have united, as in previous years, in recommending for the 1937 crop, analyses, rates per acre, and sources of nutrients in fertilizers for flue-cured, sun-cured, and shipping tobacco, and for plant beds on tobacco soils. In conjunction with this enterprise, the plant pathologists of the stations mentioned and the Department, forming themselves into a tobacco disease research council, have prepared recommendations relating to the control of downy mildew and root knot of tobacco.

Control of diseases.—Downy mildew of tobacco (*Peronospora tabacina*) was effectively prevented in flue-heated and electrically heated glass-covered hotbeds, by the Georgia Station, when a minimum temperature of 70° F. was maintained.

Root knot (*Heterodera marioni*) causes much injury to tobacco in the Georgia flue-cured belt, says the Georgia Station, but it may be controlled so far as commercial production is concerned by rotating tobacco with crops showing high resistance to nematode, especially Runner and Spanish peanuts, or by practicing fallow cultivation for two seasons.

Control of ordinary tobacco mosaic may be accomplished with measurable success through application of recommended precautionary measures, according to the Wisconsin Station, e. g., precautions against introducing the virus into tobacco fields and dissemination of mosaic after it has gained entrance into the crop. The station finds that the virus may survive in soils for one year or longer. It rapidly loses virulence under natural conditions but not fast enough to exclude soil infestation as a factor in tobacco-mosaic infection. This station, cooperating with the Department (B. P. I.), has shown definitely that tobacco streak is due to a very sensitive virus to which tobacco plants may become immune and that such immunity may become of value in the control of the disease.

An improved hybrid.—Over two-thirds of the entire acreage in the Georgia-Florida wrapper-tobacco area, says the Florida Station, was planted with seed produced by the North Florida Substation, and 75 percent of this was a hybrid type developed by the station. Such station-grower cooperation is establishing a uniformity of variety and grades of black shank-resistant tobacco for the area. This station also observed that black shank (*Phytophthora parasitica* var. *nicotianae*), a serious disease of Florida wrapper tobaccos, is influenced to a great extent by soil temperature.

Fertilizers.—Cooperative experiments by the Georgia Station and the Department (B. P. I.) have shown that phosphorus is almost entirely absent from the virgin Coastal Plain soils. Continued cultivation without application of phosphorus or residues from fertilizer on other crops will eventually result in a complete failure of tobacco. Phosphorus increases the growth of the plant and promotes ripening and thereby improves the quality of the cured leaf. Since misuse of nitrogen can destroy the quality of flue-cured tobacco quicker and more completely than phosphorus or potash, it is highly desirable to

control the amount and form of nitrogen supplied the crop. While the quantity and source of potash used markedly influence the quality of flue-cured tobacco, there seems to be slight danger of applying too much potash provided the chlorine content of the fertilizer mixture does not exceed 2 percent. Adverse effects of excesses or deficiencies of these elements on growth and quality were quite evident. Under south Georgia conditions a fertilizer analyzing 8 percent of phosphoric acid, 3 percent of ammonia (2.47-percent nitrogen) and 8 percent of potash is generally advised. Regular fertilizers under flue-cured tobacco may be very profitably supplemented by moderate quantities of pulverized, well-rotted manure. Omission of calcium, sulphur, and magnesium has resulted in distinct and characteristic symptoms of their absence, but as yet these deficiencies do not destroy the value of the crop.

The absorption of nitrogen, phosphorus, and potassium by cigar-leaf tobacco plants seems to be correlated closely with the quantities available in the soil, according to experiments by the Pennsylvania Station in cooperation with the Department (B. P. I.) on Hagerstown silt loam and clay loam. Clover and alfalfa in the rotation add considerably to the nitrogen available for absorption. Good response in yield and production of wrappers has been made to potassium and also to phosphorus, best applied in 1,000 pounds per acre of a 6–8–12 mixture. One-half ton of 0–8–12 mixture has equaled 20 tons of manure in efficiency.

The Connecticut (State) Station has found that fertilizer in which soybean-oil meal replaces cottonseed meal produces as much and as good tobacco as one containing cottonseed meal. The price is about the same, and the composition quite similar.

Insect pests.—To meet the needs of growers, the Connecticut (State) Station has issued a concise, popular treatise on the insects that injure growing tobacco plants with suggested control measures. The bulletin gives a calendar of the more important tobacco insects in Connecticut to aid growers in planning more orderly and effective control.

SORGHUMS

Planting date and row spacing.—The varied response of 10 representative grain sorghums in stands, production of grain, and total dry matter to several dates of planting 3.5- and 7-foot rows has been determined by the Oklahoma Station, experimenting during 10 years at Goodwell in the Oklahoma Panhandle. The time of planting most suitable for maximum grain production has been a date as late as possible to allow the variety adequate time to mature before frost. Wide spacing as a systematic practice has produced a larger average grain yield only from tall-growing relatively late-maturing varieties seldom used for grain production because of their low yield.

Grain and forage.—Early Kalo, a grain sorghum, and Atlas sorgo have been especially promising in recent years, according to Nebraska Station tests over a prolonged period at North Platte.

Differences between grain sorghums and corn in growth habits, heat requirements, and heat and drought endurance have resulted in differences in their response to varying seasonal conditions. In varietal tests, corn yields in 1924 and 1928 more than doubled grain-

sorghum yields, while in 1932 and 1935 much higher yields were made by grain sorghums than by corn. Grain sorghums did not result in the same beneficial effects on succeeding crops in dry-land rotation that were evident following corn. Corn was injured permanently by burning between irrigations in the hot, dry season of 1934, whereas Atlas sorgo was affected much less severely, the silage yields averaging 5.9 and 15.2 tons per acre, respectively. In 1935, with more nearly normal temperature conditions, corn averaged 14 tons per acre, while Atlas made but 11.3 tons.

Sorghums as crops for severe soil-blowing conditions.—Crop varieties found by the New Mexico Station best adapted for areas in northeastern New Mexico, where soil blowing is likely to occur, include Western Blackhull, Dawn, and Early Red kafirs, Kalo, hegari, Beaver, and Dwarf Yellow, and Sooner milos for grain; Leoti Red and Early Sumac sorgos and Sunrise kafir for forage, and several corn varieties. Sudan grass is indicated as valuable for forage and wind-erosion control, and its stubble offers excellent protection against soil movement. Emergency cover crops to be sown in late summer to protect against wind erosion include early maturing forage sorghums, as Early Sumac and Leoti Red, Sudan grass, and millet.

Disease-resistant sorghums.—The Kansas Station cooperating with the Department continued studies on the cause and control of the milo disease, and observed that sharp varietal and selection differences in resistance have been maintained. Resistant selections of Dwarf Yellow and Day milo and of Beaver and Wheatland have shown up well under test. The station found certain sorghums, such as the feteritas, kafirs, durras, and sorgos, highly resistant to the disease. The Texas Station also has several resistant strains, some of which have shown experimentally 100-percent resistance to the disease.

The accomplishments, progress, and current objectives in the improvement of the several sorghums by the stations and the Department, working independently and in cooperation, were summarized in the Yearbook of Agriculture, 1936, pages 523–560.

SOYBEANS

Soybean culture in the United States has been expanding rapidly in recent years—the production harvested for beans in 1935 being 39,637,000 bushels from 5,211,000 acres, or more than double the previous record production in 1934. The increasing importance of the crop also has been reflected in the research programs of stations in States growing extensive areas, especially in Illinois, Indiana, Iowa, Missouri, North Carolina, and Ohio. A survey by this Office in connection with the activities of the Soybean Council shows that 215 active station projects, including a number in cooperation with the Department of Agriculture (B. P. I.), dealt with the various phases of soybean research during 1936. The stations also are cooperating with the Department in the research of the Soybean Laboratory located on the grounds of the Illinois Station at Urbana.

Soil improvers.—Alternating soybeans with small grains has been found by the Missouri Station greatly to improve soil conditions and to increase yields on heavy gumbo soils in that State. Such

crop combinations more or less automatically overcome the mechanical difficulties of handling these heavy, refractory bottom lands, doubling or trebling crop yields, and at the same time reducing labor costs. This station also finds that the value of the soybean as a soil improver depends on the way it is handled and used. In ordinary harvesting either for hay or for seed, from 15 to 25 percent of the nitrogen it contains is left in the field. If only roots and stubble are left, only about one-tenth of the nitrogen of the crop returns to the soil.

Effect on corn yields.—The Louisiana Station found that if both corn and soybeans are to be grown, it is more economical to grow them both on the same land rather than on separate areas. When grown separately, the production per acre averaged 20 bushels of corn and 3,089 pounds of dry bean hay, but when grown in combination it amounted to 33.9 bushels of corn and 4,020 pounds of hay. Turning under soybeans where they were grown alone increased corn production the following year by 56 percent, 162 percent at the end of the second rotation, and 98 percent at the end of the third. The increases in corn yields, although substantial, were considerably smaller on land where soybeans were grown alone and cut for hay. Cotton on land growing corn and soybeans, for 5 years, made much more vigorous growth and better yields than cotton after corn alone.

Phosphorus and calcium.—Phosphorus is not a significant factor in controlling nodulation in the early activity of the soybean plant, according to Missouri Station research. The phosphorus in the seed and that applied were used most efficiently in the early growth period when the calcium needs of the plants were satisfied. When plenty of calcium was supplied, the crop contained more of the other nutrients as well as of the calcium. A relatively close interrelationship of calcium, phosphorus, and nitrogen and their importance in the successful growing of soybeans and possibly other legumes are evident.

ALFALFA

Alfalfa continues to be a leading forage crop in the United States, producing in 1935, 29,066,000 tons of hay from 13,567,000 acres, and its problems consequently receive much attention from the stations. The Michigan Station recently summarized the results of its research and that of other stations in a bulletin of scientific and practical information on the culture of alfalfa.

Production in the Mississippi Delta.—The Mississippi Station, cooperating with the Department of Agriculture at Stoneville, determined that while some of the failures of alfalfa in the Delta could be attributed to use of unadapted varieties, failure to cut at the proper growth stage, poor seedbed preparation, and to insect and disease injury, the major factor in successful alfalfa production is adequate surface drainage. The natural drainage on the level to nearly level areas of Sharkey clay "heavy buckshot" soils, it was shown, should be supplemented by building the fields up into lands with surface ditches spaced at regular intervals to drain the field more rapidly.

Seed production.—Research at the Uintah Basin Alfalfa Seed Farm of the Utah Station, concerned with cause of low alfalfa seed

yields, suggested that contributing factors have included subnormal precipitation with its effects on relative humidity; common stripping, due to unfavorable weather conditions; bud blasting, due in part to lygus bugs; and enforced self-pollination. Additional investigations on causes of alfalfa seed failures were also made in Millard County, Utah. Factors found to favor alfalfa seed production in this area include rather limited water supply, sufficing for proper functioning of the plant during blooming and seed formation; growing the crop in hills and rows; cultivation only for control of weeds and insects; clipping at early bud stage or pasturing until May 15; and harvesting when about two-thirds of the burs have turned brown, but before they blacken. Climate, weather, and insects did not seem to be major factors controlling seed production, nor were fertilizers effective. Farms with medium-texture soil have produced seed most consistently.

Fertilizers.—Application of fertilizer to alfalfa by the Washington Station usually has resulted in increased yields on both eastern and western Washington soils, the average yield on eastern soils exceeding that on western soils irrespective of fertilizer treatment. While the amount of nutrients absorbed per ton of hay was greater on the former soils, the quantity removed per acre was much in proportion to yield in both areas. Climatic conditions exclusive of available water seemed to influence the composition of alfalfa in the two areas of the State. Alfalfa grown in the humid area of western Washington generally had a higher phosphorus content than that grown in the arid area of eastern Washington. The hay usually has contained enough phosphorus and calcium for general feeding purposes of livestock and for the high requirements of lactating dairy cows.

Observing widespread deficiency of available phosphorus in Idaho soils, often insufficient to produce maximum crops of alfalfa, the Idaho Station finds that where phosphatic fertilizers produce an appreciable increase in yields of alfalfa, they also increase its phosphorus and protein contents and its value as feed for farm animals. The New Mexico Station finds that alfalfa on Gila silt loam needs phosphorus but not other fertilizers. Applications of 45-percent superphosphate, 135 pounds applied each year, and 180 pounds applied in alternate years, have been most profitable.

Depletion of subsoil moisture.—The depletion of subsoil moisture by alfalfa and other crops in regions of deficient rainfall has been studied by the Nebraska and Kansas Stations cooperating with the Department. Results have indicated that alfalfa growing continuously on the same soil for several years under conditions of limited rainfall reduces the available supply of moisture in the subsoil to depths much below the normal penetration of seasonal precipitation. The Kansas Station found that alfalfa cropping depleted the soil of available moisture to a depth of nearly 25 feet. Clean fallow restored available subsoil moisture to a depth of 25 feet in about 2 years, but a subsequent seeding of alfalfa again depleted this moisture in about the same length of time. The growth of sweetclover for either 1 or 2 years under limited rainfall conditions, it was observed, may result in drying the soil to a depth which may prevent the use of moisture at a lower level by subsequent alfalfa

crops. Soybeans during one season did not result in the development of a dry layer below the sixth foot.

CLOVER AND LESPEDEZA

Winter hardiness in red clover.—Comparing the properties of the winter-hardy Ohio red clover and the less hardy French variety, the Maryland Station found that adaptability to cold is associated with a larger unfreezable: freezable water ratio and osmotic pressure value; a slightly higher pH value; greater concentrations of total sugars, dextrins, starch, and total and nonprotein nitrogen; and lower moisture content and specific conductance value. Other carbohydrates determined, as well as proteins and ash, often were greater in the nonadapted clover. Indications are that the adaptability of the red clover plant to winter conditions is associated closely with its metabolic rate.

Ladino clover.—A pink-flowered, brown-seeded Ladino clover, 2 weeks earlier and more winter hardy than the original strain, has been developed by the Idaho Station.

Korean lespedeza in crop rotations and pastures.—Korean lespedeza, according to Missouri Station studies made in part in cooperation with the Department, furnishes an abundance of highly nutritious pasturage through the summer and early fall; is valuable for hay, with good yields and curing easily; will grow well on any farm land in Missouri, although in some places growth may be improved by lime or phosphate; if pastured, will rapidly add nitrogen and organic matter to the soil; is established at a very low cost; is a remarkably safe crop in Missouri; and is the key crop in a series of new highly productive rotations. In 1935 it was grown on more than 2,000,000 acres in the State.

Lespedeza sericea.—In Tennessee Station experiments, extending over several years, the perennial *Lespedeza sericea* has proven to be a long-lived perennial legume, apparently able to endure a good deal of shade, zero weather, and severe droughts after being once established; has held its own against weeds, diseases, and insects; and has shown no evidence of becoming a pest. Indications are that *L. sericea* will be valuable for hay, pasture, soil improvement, and erosion control.

OTHER LEGUMES

Improved peanuts.—Seeking high-yielding peanuts, with the attractive appearance and sweet flavor of Spanish and the nonsprouting tendency of runner peanuts, a Jumbo peanut that fills well, and a hay type, the Florida Station finds from its extensive breeding work that best success probably will be with crosses of Spanish and runner or Jumbo peanuts.

Selection from F_2 and F_3 generation crosses between Carolina runner and Spanish peanuts, by the Georgia Station, has provided strains resistant to disease and more productive than either parent. Two intermediate selections made about 2 tons of hay per acre and a larger yield of nuts than the Spanish peanut. This station has found peanuts to be highly resistant to the root knot nematode, a characteristic of particular significance in connection with crops rotating with tobacco where such resistance is highly desirable.

Soil treatment as related to nodulation of peanuts.—The use of calcium carbonate and calcium sulphate in growing large-type peanuts is extensively practiced in North Carolina and, under some conditions, application of either or both of these materials may mean the difference between crop failure and success, whereas elsewhere they are of no apparent value. The North Carolina Station attributes the effect of such applications, in part at least, to their influence on soil acidity as related to root nodule fixation of nitrogen. Calcium carbonate applied at the rate of 1 ton per acre has increased nodulation of peanuts throughout the season on two acid soils tested, but not on soil previously limed. Moderate quantities of calcium carbonate stimulated and increased nodulation, whereas heavy applications retarded and reduced it. Calcium sulphate broadcast at the rate of 1 ton per acre both delayed and reduced nodulation in all three soils. Sulphur, at the rate of 400 pounds per acre, prevented nodulation at all growth stages. Calcium carbonate decreased, calcium sulphate slightly increased, and sulphur greatly increased the acidity of the soils used.

Field bean production.—Yields of field beans, the New Mexico Station reports, have been influenced by time and rate of planting, amount of soil moisture available for germination, number of irrigations, amount and distribution of rainfall, particularly in July and August, bean beetle infestation, hailstorms, and soil fertility. Productive practices include planting June 1 to 7, three irrigations properly spaced during the growing season, the heaviest seeding rate used with pinto beans, about 40 pounds per acre, and plowing under pea vines on both irrigated and dry land. This station has developed several promising strains of pinto beans, giving attention to uniformity of pod setting, yield, and size and mottling of the beans. Mottling is especially important in view of the market demand for a brown bean, mottled with a white background.

Tepary beans have been found by the Oklahoma Station to be the surest and most profitable legume hay crop for the Oklahoma Panhandle, surpassing cowpeas, mung beans, and soybeans, in order. Its studies indicate that green-shelled tepary beans are as valuable as cowpeas or lima beans for human food.

Vetch and related crops.—Many stations, especially in the South, are considering the merits of winter legumes for cover, green manure, and soil conservation, as well as for forage. Hairy vetch, the Ohio Station finds, is the best legume cover crop for orchards cultivated during the summer, a valuable addition to rye for pasture or cover and green manure, and, sown with wheat, a very nutritious hay for emergency seeding.

Observing that profitable increases in corn and cotton follow properly handled green manure of hairy vetch and Austrian winter peas, the Alabama Station, from its experiments, indicates cultural practices. Essentials for the success of these legumes for soil improvement include early (Sept. or Oct. 1 to 15) planting, preferably drilled, of inoculated seed at the rate of 20 pounds per acre of hairy vetch and 30 of Austrian winter peas; using 300 to 400 pounds of superphosphate or 600 of basic slag except on land well fertilized with phosphorus for several years; and turning under in the spring when

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the green tops from 100 square feet weigh 15 to 20 pounds, delaying the planting of the succeeding crop at least 2 weeks afterward.

Crotalaria in the South.—The value of crotalaria for green manure, cover, and soil improvement has been demonstrated by the Florida, Georgia, South Carolina, and Mississippi Stations, in cooperation with the Department. The Florida Station has found crotalaria, especially *Crotalaria spectabilis* and *C. striata*, to be a promising summer cover crop in the Southeastern States. The Georgia Station finds *C. spectabilis* to be well suited to sandy soils in the Coastal Plain. It is a heavy yielder and late growing, but enough seed generally mature before frost to insure reseeding. Fall-sown oats planted after a crop or two of *C. spectabilis* may be cut and a good stand of volunteer crotalaria may be expected. This practice is rather important as a soil-building measure and requires no man or team labor for seeding the crotalaria.

Sesbania or wild hemp.—Sesbania or wild hemp, a summer legume, has been found by the New Mexico Station to be especially well adapted for green manure in southern New Mexico. Sesbania has been ready to turn under for green manure in from 7 to 9 weeks after planting. If turned under before the seed matures, the plant decomposes rapidly with no volunteer plants in succeeding crops.

Drilling fine limestone for legumes.—Limestone, according to Missouri Station research, supplies calcium as a nutrient as well as for correction of soil acidity. The requirement of finely ground (about 40-mesh) material and the greater effectiveness of smaller quantities drilled compared with broadcasting are pointed out. Fine limestone can be drilled with the fertilizer attachment of the grain drill when legumes are spring-planted or with wheat or other nurse crop in autumn. Drilling limestone for each legume crop in the rotation is advised. Drilling effects a substantial saving in labor as well as in limestone.

GRASSES AND HAY

Fertilizers and cutting treatments for timothy.—Timothy continues to be a popular hay plant, especially in the Northern States. The Maine and Michigan Stations found that the yields and also quality of timothy hay, as in a higher protein content and yield of protein per acre, can be improved by the proper use of fertilizer on the meadows. The Maine, New Hampshire, and Pennsylvania Stations secured a more nutritious timothy hay by cutting the crop early. Findings by the New Jersey Station indicate that a spring application of nitrogen fertilizers, i. e., ammonium sulphate and sodium nitrate, and a second treatment at the early heading stage, with the timothy cut about 10 days after treatment, will result in increased yields of hay of high feeding value. The feeding value of early-cut timothy has also been noted by the Pennsylvania Station, which found that timothy sown with alfalfa helps to prevent heaving of the alfalfa roots, while the alfalfa promotes early cutting of the timothy. The Ohio Station observed that timothy sown in thin alfalfa meadows after the last fall cutting has decidedly increased the amount of hay at the first cutting the following season and lowered the weed content.

Improved timothy strains.—The high variability in commercial timothy has made possible by continuous selection through several generations, in cooperative breeding work by the Ohio Station and the Department, the development of strains having longer stems, earlier or later maturity, and better retention of green color in the leaves than the plants from which they were derived. The plants of many of these new strains, e. g., Huron, show a high degree of uniformity even though grown under natural conditions permitting open pollination.

Composition of Kentucky bluegrass.—Its studies of the influence of fertilization, irrigation, and cutting on yield and composition of Kentucky bluegrass showed the Wisconsin Station that available nitrogen and water are the two most important limiting growth factors. Nitrogen, in conjunction with mineral fertilization and irrigation, consistently doubled and sometimes trebled the yield of grass. The crude protein produced per acre varied directly with the amount of nitrogen fertilizer (ammonium sulphate) applied. The grass, when mowed to ground level, produced higher season yields than when it was cut higher, that is, 1.5 inches. Grass cut when 8 to 10 inches high to ground level gave only slightly greater increases in yield than that cut when 4 to 5 inches high.

Native grass as affected by periodic clipping.—The Oklahoma Station, comparing variously clipped and fertilized plats with pasture and roadside plats, found that clipping native grass more than twice a year did not return enough additional production in the fifth year to pay for the labor, and production declined as the number of clippings increased. The greatest yield of air-dry hay came from grass clipped twice and receiving manure and phosphate 6 years before. The least top weight was secured from grass clipped 8, 9, and 10 times annually, which also produced least root weight. The greatest root weight came from unmolested roadside grass.

Hays and haying methods.—Haymaking experiments by the Michigan Station, in the Upper Peninsula, show that the length of time required for curing hay is largely influenced by prevailing weather, moisture content at cutting, yield, and type of hay. At cutting, legumes contain more moisture than timothy, which, however, usually is ready to store sooner. Addition of timothy to legumes grown for hay as an aid to curing seems a questionable practice unless timothy predominates in the mixture. Timothy grown in such mixtures was darker green, leafier, and taller, and contained a higher percentage of protein than timothy grown alone. Partial curing in the swath until the hay was well wilted, followed by windrow-curing, resulted in better hay than from complete swath-curing, generally the more rapid curing method.

Comparative value of roughages.—Cereals have a certain advantage for emergency hay purposes, when the customary hay crops are short. In chemical analyses of Albit wheat, Horsford barley, Rosen rye, and Markton oats cut at immature stages, approximately 6 inches high, the Washington Station found that the dry matter was practically identical with that of alfalfa and sweetclover plants. In similar trials with hays, Markton oats, Bluestem wheat, Albit wheat, and Horsford barley cut at the medium-dough stage were most

palatable. Digestion trials with cereal hays cut at this stage show Horsford barley hay first in total digestible nutrients, Markton oats second, Albit wheat third, and Bluestem wheat hay fourth.

PASTURES

The growing appreciation of the importance of good pastures in economical livestock production, as well as in other phases of farm management, as for replacement crops and soil conservation, is reflected in increased station activity in pasture investigation and in published reports giving practical applications. For example, the Kansas and Louisiana Stations each recently published practical bulletins on pasture production and management, based on their research. The wide scope and varied character of pasture research in the Nation is shown by the digest of literature of pasture research in the continental United States and Canada, 1885–1935, prepared by the Bureau of Plant Industry. It embraces 565 separate reports from the stations in addition to nearly 100 from the Department of Agriculture and a number from Canada and other sources.

Fertilization.—Substantial and profitable increases in production have been derived from the use of fertilizers on pastures by the Arkansas, Connecticut (Storrs), Kentucky, New York (Cornell), Ohio, Vermont, and Virginia Stations.

The Arkansas Station finds that greatly increased production at low cost is possible by applying phosphate (and lime where needed) on pastures having a reliable grass base with early legume supplements such as hop, bur, and white clovers. Its grazing tests have shown seasonal increases of 42 percent on typical lowland soil and 120 percent on Coastal Plain soil over returns from nitrogenous fertilizers and at lower costs per acre and under conditions of meager rainfall during midseason.

Application of a complete commercial fertilizer has greatly improved the plant growth and carrying capacity of lowland pastures for the Georgia Station, but the most economical gains have been made from moderate quantities of phosphorus, especially where white clover is included.

Application of ground limestone with superphosphate or manure, the South Carolina Station found, will about double pasture yields on sandy clay loam soils of the piedmont section of South Carolina at a very nominal cost.

Summarizing the results of its bluegrass pasture experiments over 20 years, the Virginia Station reports that fertilizing the pasture has increased the yield of total digestible nutrients 60 percent but that rotation of animals resulted in no increase. Furthermore, a large residual effect from the fertilizers is expected for several years.

While the clay soils of the Champlain Valley are about the only soils in Vermont shown by the Vermont Station to contain much of and perhaps enough potash, certain crops on these soils have responded to additional potash provided that clover is predominant. This seems significant because clovers need much more potash than do pasture grasses. Grasses have usually responded to small applications of potash, e. g., 75 to 100 pounds of potassium chloride, yet heavier applications have often resulted in decreased yields, whereas pasture clovers have continued to respond to each increment of

potash. Since plant response to added potash depends on the amount of white clover present, means of maintaining and increasing the growth of this desirable plant in pastures are suggested.

The seasonal variations in the reaction, nitrates, and ammonia of soils from its differently fertilized permanent pastures have been determined by the Connecticut (Storrs) Station. The ammonia contents have been higher in spring and autumn than in summer. Nitrates have always been present, usually in very small amounts. The highest lime requirements usually have occurred in midsummer and the lowest in autumn, but as in the case of nitrates, there have been no distinct seasonal trends.

Management and improvement.—Frequent removal of top growth of pasture grasses by grazing or mowing, the Florida Station shows, has resulted in better utilization of applied nitrogen and a more nutritious herbage higher in protein and mineral content than when such grasses are allowed to reach a more mature stage of growth before being grazed or mowed. The station also observes that native pasture grasses of species of the genera *Aristida*, *Andropogon*, *Sporobolus*, and *Sorghastrum*, when burned over annually, have given heavier beef production than when unburned.

The Ohio Station obtained good response in its pastures from lime, phosphate, and manure on the generally depleted pasture areas. Once they have been applied to the general pasture area, there may yet be a shortage of pasture in early spring and July and August or sometimes even in May and June. For the early spring period the station recommends that an area of good bluegrass sod be set aside, and in addition to periodic applications of lime, if needed, phosphate, and possibly manure, it should receive annually in early spring a liberal application of nitrogen fertilizer. Since livestock will prefer this nitrogen area, it must be fenced separately from the main pasture area and protected from overgrazing. Little or no grazing should be permitted after September 1. If Kentucky bluegrass sod is not available, timothy, orchard grass, or tall meadow oatgrass may be used, or a special crop such as rye may be substituted. For the July-August period, Sudan grass, alfalfa, or alfalfa mixtures are recommended. Should this leave a shortage in the main grazing season, nitrogen may be applied to the main pasture area further to boost growth at that time, this being especially desirable in years of a low white clover content.

Many farmers in western Oklahoma and Texas, as a result of experiments at the Spur Substation, Texas, are terracing their pastures and listing them along contour lines with very beneficial results. Contour furrows run about 4 feet apart and about 4 inches deep have proved highly effective in reducing run-off and holding the water on the soil, where it soaks in and improves the grass growth.

An experimental machine for making large basins in hillside pastures and orchards, designed and built by the Iowa Station, has been used on plats in eight counties in Iowa. The basins formed are about 3 by 9 feet and may be as much as 12 inches deep. Field measurements indicate a capacity of about 4 inches of rainfall. A 20-horsepower track-type tractor is required for satisfactory operation on hillsides.

Permanent pasture plants.—The Georgia Station obtained a satisfactory growth of carpet grass, Dallis grass, and lespedeza on lowland permanent pastures, but the tendency was for carpet grass to choke out the other plants within a few years. White clover made successful growth on well-drained lowland soils high in organic matter, or on fertilized areas. Occasional prolonged droughts during the summer seriously affect the production of upland permanent pastures. However, the station has obtained fairly satisfactory gains from beef animals grazing on a mixture of Bermuda grass and common lespedeza. For temporary pasture, the Georgia Station finds that steers make satisfactory gains on kudzu. Either continuous or alternate grazing of one steer per acre has not resulted in overgrazing this crop. The station also finds that a thick fall seeding of oats followed by common lespedeza is a desirable combination to supplement permanent pastures.

Comparative tests of carpet grass, Bermuda grass, Bahia grass, and centipede grass, in pure stands, and a mixture of all four, by the Florida Station in cooperation with the Department, show that mowed yields have been highest in the Bahia grass and mixed-grass pastures and lowest in the pasture of centipede grass, attributed to its more prostrate growth. The highest percentages of crude protein have been obtained from the carpet grass and the lowest from the centipede grass pasture. Cattle made the heaviest gains on the centipede grass and the lowest gains on the carpet grass pasture. Except with the centipede grass pasture, there was a close correlation between mowed grass yields and cattle gains.

By monthly clipping of pasture consisting of white clover, rye, and Dallis, Bermuda, and carpet grasses, the Louisiana Station has shown that highest yields have been obtained in April and August and the most nutritious grass in May, June, and July. February or March grass contained about 80 percent moisture, and that of late summer averaged about 70 percent. February grass contained nearly twice as much crude protein as that cut in September.

Sudan grass, the West Virginia Station reports, is a very satisfactory pasture crop after July, when other pastures are likely to be dry, as shown in experiments with bluegrass and first-year sweetclover. Practically all of the total green feed from Sudan grass came after August 1, whereas but half or less of the total yield of bluegrass and first-year sweetclover came after that date.

Species which have maintained good stands 3 years or longer under either cutting or grazing, in the extensive tests of the Connecticut (Storrs) Station, include Kentucky bluegrass, the bents (including redtop), orchard grass, timothy, reed canary grass, and sheep's and Chewing's fescues, and Ladino clover and wild white clover in mixtures, and Grimm alfalfa alone. The fescues have been very unpalatable and reed canary grass rather low in nutritive value and in yields on well-drained soils. The simple mixtures (one grass and one legume), have yielded as well or better for 3 years than those containing several species. Ladino clover seeded with a grass was outstanding in both total and late summer yields. Animals preferred bromegrass, timothy, and meadow foxtail and avoided sheep's and Chewing's fescues. Red, white, and alsike clovers were grazed in preference to all grasses.

Range plants.—Stations in the Western States, usually working in cooperation with the Department, continued to study problems of range management and the restoration of depleted ranges by reseeding and other practices. An example of efforts being made to handle such problems more effectively is the extensive grass-breeding garden recently established near Logan, by the Utah Station cooperating with the Department. A primary objective is to develop improved plants suitable for ranges and pastures in that region.

Many feel, particularly in light of disastrous effects of recent drought and dust storms, that a serious mistake has been made in plowing up buffalo grass and other native grasses in the zeal to grow wheat and other cultivated crops. The Kansas Station, cooperating with the Department, has found that this mistake may be corrected in measure by transplanting small pieces of buffalo grass sod in well-prepared soil at intervals of 3 to 4 feet. Such pieces will spread and cover all intervening spaces by the end of the third season, while from 20 to 50 years are required for buffalo grass to become reestablished naturally on abandoned farm land.

Demonstration by the Montana Station that, with the use of crested wheatgrass, dry-land pastures may be established in from 2 to 3 years on land on which wheat growing is now an uncertain practice will undoubtedly be of great value to stockmen. The station has also worked out practical methods whereby crested wheatgrass may be used in regrassing large areas of land formerly farmed. The station has shown that the grass requires temperatures below 20° C. (68° F.) during the first few months after harvest for complete germination; satisfactory germination can be secured at all times by prechilling or by germinating at a constant temperature of about 15°.

Attempts by the New Mexico Station to reseed ranges having 13 inches of rainfall have resulted in good stands of blue grama, crested wheatgrass, slender wheatgrass, bromegrass, and chamiza. Grimm and Ladak alfalfa also have possibilities for use as range supplements in areas where the water table is near the surface. The station reports that with sufficient moisture Johnson grass will provide abundant grazing practically anywhere in New Mexico except in high mountains and in compact soils. Under certain conditions, especially on irrigated land, it is a serious weed pest.

Little bluestem (*Andropogon scoparius*) and sandgrass (*Calamovilfa longifolia*), generally regarded as of little value because of low palatability, have been found by the North Dakota Station to increase markedly in palatability as a result of heavy grazing during drought. Apparently they may be regarded as valuable emergency forage for winter grazing following dry summers.

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HORTICULTURAL RESEARCH

Appreciative of the need for better quality fruits and vegetables rather than increased quantities, the trend of horticultural research during the year continued along lines of developing higher quality products, not only as the products left the orchard and garden but as they reached the ultimate consumer. This program included the breeding and testing of new varieties, the development of more effective cultural methods, better protection from insects and diseases,

and improvements in methods of handling fruit and vegetables during storage and movement to markets. Of outstanding importance were studies relating to the development of new fungicides and insecticides, particularly to replace present toxic materials such as arsenate of lead. Notable progress was made also in plant-nutrition studies as related to various minor elements such as copper, magnesium, boron, manganese, and zinc.

FRUITS, NUTS, AND COFFEE

New and better varieties.—The agricultural experiment stations continued to take the lead in the important task of developing improved varieties of fruits and vegetables to better meet the exacting requirements of modern specialized uses and conditions. In search of better fruits that can withstand the low temperatures and drying winds of the North Central States, the South Dakota Station continued its work in hybridizing native plants with introduced species and reported the successful production of apples, crab apples, and plums that appeared promising from the viewpoints of hardiness and better quality.

The nearby Minnesota Station facing somewhat the same problems as the Dakotas continued actively its program of fruit breeding and reported the naming of two more seedlings, namely, the Beacon apple and the Ember plum. The Beacon apple is described as of attractive solid red color, maturing a few days later than Oldenburg and superior to that variety in flavor and handling quality. The Ember plum, described as yellow in color with an attractive red blush, is said to be of good quality and the trees vigorous and productive.

Peaches superior in quality to existing commercial varieties continued to result from the long-continued and productive breeding studies at the New Jersey Station. Among new varieties that have been produced and distributed by the station are Buttercup, Cumberland, Delicious, Eclipse, Golden Jubilee, Goldfinch, Marigold, Massasoit, Meteor, Oriole, Pioneer, Primrose, Radiance, Rosebud, and Sunbeam. Some of these are said to be replacing the older commercial varieties.

The J. H. Hale peach, desirable in color, size, and quality, but almost completely self-unfruitful, may be replaced by a self-fruitful type found in Georgia. According to the Georgia Station this new peach should be valuable for growers who wish to produce the Hale type of peach but have been prevented hitherto by its unfruitfulness.

A fuzzless peach equal in size to Belle was announced by the Virginia Station. The fruit is said to be of good quality and the tree fully hardy for Virginia.

Apricot varieties hardy in North Dakota and of fair quality resulted from crosses made by the North Dakota Station between hardy Siberian introductions and the high-quality California varieties.

The extensive breeding studies with citrus carried on by the California Station at Riverside resulted in four newly named varieties, namely, the Trovita orange and the Kara, Kinnow, and Wilking mandarins. The Trovita orange was particularly interesting because it was produced from seeds found in a fruit of the normally seedless Washington Navel orange. Preliminary observations suggested that the Trovita orange is capable of setting and maturing larger crops

in some of the drier valleys than is possible with the wholly seedless varieties.

Bronx Seedless was the name given a new hardy seedless grape developed jointly by the New York State Station and the New York Botanical Garden as an incidental product of 16 years of research on the nature and causes of seedlessness in the grape. The new variety is said to resemble Delaware in general appearance, with the clusters and berries considerably larger. Because of softness of the berries the chief value of the new grape is believed to be for local use by home gardeners and for sale at roadside stands. Several other promising grape seedlings of the seedless type are now awaiting naming.

New black raspberry seedlings produced by the Iowa Station from crosses of Black Pearl and Quillen are said by the station to be highly promising on account of their resistance to anthracnose, their vigor, and fine quality of fruit. One seedling was considered particularly valuable because of early and uniform ripening which permitted the harvesting of the entire crop in one or two pickings, thus enabling the growers to avoid the heat and drought which often prevail about the time black raspberries mature. The leaf-bud method of propagation developed at the Iowa Station was used to advantage in propagating the raspberry seedlings.

Four new raspberries were named and introduced by the New York State Station during the year. The Evans black raspberry derived from a cross of the Watson Prolific and Honeysweet varieties was reported as extremely vigorous and productive and producing fruit of good quality. The Taylor red raspberry introduced in the fall of 1935 was characterized by fruit of unusually large size, long conic shape, and high quality. The Indian Summer red raspberry produces a large crop of fall berries as well as a desirable spring crop. The Marcy red raspberry named for Mount Marcy, the highest peak in New York State, was said to be even more productive than Taylor and to be relatively resistant to virus diseases.

From crosses between black and red varieties of raspberries the North Dakota Station secured purple-fruited seedlings possessing marked resistance to red spider.

Known at present simply as New Jersey No. 35, a promising new midseason strawberry was distributed by the New Jersey Station for testing. This variety is said to be a heavy yielder of bright red fruits above average in quality, with the plants and fruit resistant apparently to common strawberry diseases.

Better cultural practices.—With rising cost of producing high-grade fruit, ways and means of increasing the efficiency of production were given serious consideration by the various stations located in fruit-growing regions.

The importance of locating orchards on favorable sites was stressed by the Michigan Station, which, following a study of the general situation within the State, reported that the best orchard sites, where profitable production is most likely to be secured, are located on broad ridges or upland plains bordering depressions or on loamy soils underlain by gritty clay of relatively open structure situated within 3 or 4 miles of Lake Michigan. Furthermore, the station advised that unfavorable sites should not be utilized for new orchard plantings under present economic conditions.

That orchard plants may in semiarid regions deplete gradually the subsoil of moisture was the finding of the Nebraska Station after several years' observations in an experimental orchard at Union. Apple trees were found to exert an effect on soil moisture comparable to other deep-rooted plants, such as alfalfa, except that more time was required to approach the harmful end effect. The number of trees, their age, and their variety were factors of importance.

The maintenance of soil fertility in the apple orchard, long a subject of careful study at the Pennsylvania Station, is believed possible by plowing under on a short-rotation basis heavily fertilized sods, or, in the case of orchards too dense for good grass growth, by the addition to the soil of green material grown outside the orchard area.

Recognizing nitrogen as the major fertility need of apple orchards, the Virginia Station nevertheless concluded from extensive studies that as the orchards mature and root foraging progresses the application of other elements, such as phosphorus and potassium, give favorable responses. In fertile soil apple trees may produce profitably for from 20 to 25 years without showing a need for any applied element except nitrogen.

From the experience of the Missouri Station, located in a region of younger soils from the viewpoint of duration of culture, nitrogen, particularly in an available form, is the most important element for the maintenance of desirable growth and yield of fruit trees. It was conceded that, while fruit trees may be grown without fertilizer on particularly favorable sites, in the long run the crops would not be satisfactory. Time-of-application studies conducted by the Missouri Station indicated that fall is a better time than spring to apply nitrogen fertilizers, particularly so in the case of the more slowly available materials, cyanamide and sulphate of ammonia, rather than nitrate of soda.

Heavy applications of nitrogen were found by the California Station to have little effect on the color of Gravenstein apples, but color was slightly improved by ringing the main scaffold limbs in the first week of May.

That mulching of apple orchards is a feasible practice under certain conditions was demonstrated by the Massachusetts Station. The mulch was found to lower the soil temperature in summer and to increase it somewhat in winter. Mulching conserved soil moisture during dry periods, and after the first 2 years there were abundant nitrates beneath the mulch. The practice of mulching is said to be particularly desirable for orchards located on comparatively steep slopes where erosion would follow clean culture or where stones or irregular contour interfere with cultivation. In the case of varieties that drop considerable fruit near harvest time a heavy mulch prevents serious bruising and increases the percentage of salable fruit. For economy there must be an abundant nearby source of mulching material, such as low-grade hay. Hazards accompanying the mulching practice are said to be fire and mouse injury to the roots and crowns.

Continued mulching for 10 years with manure or 4 years with hay was observed by the West Virginia and New York (Cornell) Stations working together to bring about a considerable increase in the

moisture equivalent of the soil. Two years of hay mulch did not cause any significant change in the moisture.

Of three grasses, namely, Kentucky blue, orchard, and couch, the orchard grass was found by the Vermont Station to be the most persistent in the orchard and to provide abundant mulch for the trees. The orchard grass was relatively tolerant to partial shade. Annual applications of nitrate of soda appeared to have been an important factor in promoting the longevity of the grass and increasing yields of fruit.

A pruning practice involving the removal of thin, weak branches from apple trees was suggested by the Michigan Station as a means of reducing the percentage of inferior fruit and increasing monetary returns. Such pruning did not upset the bearing habit of young trees and in older trees facilitated spraying, fruit thinning, and harvesting, and, because of the decreased water-sprout growth, there was less fire blight in the trees pruned according to the thin-wood method.

As a result of long-continued experiments, the New York State Station concluded that moderate annual pruning of apple trees is decidedly better than heavy pruning. Low-headed trees with bottom branches not more than 20 inches from the soil were superior to high-headed trees, blooming earlier in their life and making larger and more substantial trees.

An examination of the soil collected in 56 commercial peach orchards led the Connecticut (State) Station to conclude that peach production is favored by a moderately heavy-textured soil of upland character and overlying a fairly porous, well-drained substratum. The peach accommodated itself to a considerable range in soil acidity.

From the results of long-continued investigations the Delaware Station reached the conclusion that peach trees in general gave better returns from nitrogen derived from inorganic sources, such as nitrate of soda, sulphate of ammonia, and calcium cyanamide, than from organic materials, such as dried blood, tankage, and manure. The price per unit of nitrogen was found to be an important factor in determining the sources of nitrogen for peach orchards, and leguminous cover crops proved useful in supplying a part of the nitrogen, particularly in the early years of the orchard.

In peach-fertilizer studies, conducted by the Arkansas Station, all the nitrogen carriers under test gave good results, but the effects obtained with phosphorus and potash fertilizers were such as to suggest that these materials are not ordinarily needed by the peach.

The potential effect of nitrogen on the time of ripening of peaches was shown in experiments by the Georgia Station in which Elberta peaches were retarded as much as one week in reaching maturity by increasing the nitrogen in the fertilizer mixture. At the same time the nitrogen increment exerted no apparent influence on resistance of the trees or buds to winter injury.

Favorable effects both in growth and production were observed by the Idaho Station following applications of sulphate of ammonia to bearing prune orchards.

Applications of sulphur or of acids were found helpful by the Arizona Station in correcting such nutritive disturbances of citrus

trees as chlorosis and crazy top, which are apparently induced by alkaline conditions in the soil.

Potash was found to be an important element in fertilizers for red raspberries by the Rhode Island Station. On the soil utilized potash was as valuable if not more so than nitrogen, whereas phosphorus was found of little direct value to red raspberries but of possible importance in promoting the growth of cover crops and thus maintaining the organic matter in the soil.

Although both nitrate of soda and cottonseed meal used singly were found by the North Carolina Station to increase the yields of strawberries growing on sandy loam soil, it was evident that when firmness and shipping quality were considered a combination of organic and inorganic nitrogen was more desirable.

Strawberries growing in highly acid soils near Plant City, Fla., were found by the Florida Station to suffer severe injury from root killing. This deleterious condition was overcome by applying sufficient agricultural limestone to the soil prior to setting the plants to bring the reaction to approximately pH 5.5.

The favorable response secured by the Wisconsin Station from applications of nitrogen and phosphorus fertilizers to cranberry bogs and the lack of response to potassic materials led to a recommendation in favor of nitrogen and phosphate fertilizers in applications of 600 pounds per acre of a 7–16–0 (NPK) mixture.

With proper conditions, which included potentially productive varieties, ample organic matter in the soil, and a soil adapted to pecan growing, good results were secured by the Florida Station from applications of a well-balanced complete fertilizer to pecan orchards. There were indications that nitrogenous fertilizers applied during July were helpful in maintaining annual nut production.

From fertilizer studies with grapes continuing over a period of 25 years the New York State Station concludes that of the three major plant foods nitrogen is the most important element, producing more and better fruit and more vigorous growth. Potash used in combination with nitrogen and phosphoric acid was apparently beneficial, but phosphoric acid used alone was of doubtful value except for its indirect influence in promoting better growth of the cover crops. Lime apparently depressed yield of both fruit and of wood.

Under the trying conditions of the northern Great Plains the North Dakota Station found that apple trees grown in bush form, that is, with branches arising at the soil level, made more rapid growth and bloomed earlier than did trees with trunks. As a result of the study it is suggested that this type of training may be of material benefit in the culture of not only apples but other fruits grown under unfavorable conditions.

That the strawberry responds rather definitely to soil reactions was shown in studies conducted by the Virginia Truck Station in which plants grown on soils of pH 6 yielded approximately 400 percent more fruit than plants grown on soil of low organic matter and of a reaction between pH 4.2 and 4.4.

Confirming the earlier findings of the New York State Station, the Arkansas Station reported that production and vigor of certain American grapes, notably Moore Early and Campbell Early, were

improved by grafting on vigorous rootstocks, such as Cynthiana and Wine King. The results were such as to indicate that grafting of grapes is a practical and economical procedure under Arkansas conditions.

Believing that the production of dwarf pear trees in the eastern United States has been limited by a lack of hardy quince rootstocks, the New York State Station began experiments in the propagation of selected quince stocks by cuttings and found that heel cuttings were distinctly superior to straight cuttings.

Rapid propagation of both the highbush and lowbush blueberry was accomplished by the Michigan Station by taking young side shoots in June. With this method much more material was available in a single plant, and although this form of propagation is not recommended as a substitute for the standard practice, it may be used to advantage in supplementing the usual practice.

High potassium as well as high nitrogen content of fertilizers was found by the Hawaii Station to be beneficial to the coffee plant in maturing of the berries. Growers using a 9–5–13 (NPK) fertilizer reported uniformly good results.

Observing that coffee trees growing in full sunlight gave much larger yields of berries than did trees in varying degrees of shade, the Puerto Rico Station concluded that most of the coffee orchards on the island are employing too much shade to give maximum yields. However, the poor appearance and lack of vegetative vigor of trees in full sunlight indicated that some degree of shading is necessary to maintain coffee trees in a vigorous, healthy condition. There was some indication that trees required more shade when young than when they approach maturity.

Protection against insects.—The codling moth, perhaps the most important fruit insect of all and at the same time one of the most difficult to control, received considerable attention during the year at several of the stations. Following up a new line of attack, definite progress was recorded by the Indiana Station in the development of light traps for the control of the codling moth. It was found that blue and white lights were the most alluring of the usual colors, but that the position of the light in the orchard was an even more important consideration than color. Lights placed in trees carrying full crops of fruit and located above the surrounding trees were peculiarly effective. Lights were also helpful in the destruction of moths in the packing house.

Chemically treated bands when properly prepared were found by the Missouri Station to kill over 97 percent of all the codling moth larvae that entered. Bands dipped in a cold solution of β-naphthol oil thinned with gasoline were equally as effective as those treated with hot β-naphthol alone. According to the station the codling moth epidemic reached a peak in 1932 and 1933 and since then has been diminishing, due to several reasons, notably better timing and placing of the sprays, the screening of packing houses to prevent the return of moths to the orchards, scraping and banding of trees, destruction of wormy fruits, and improved orchard sanitation.

That the lead-residue problem may be completely solved by substituting calcium arsenate or other nonlead materials for lead arsenate was suggested by the Washington Station as the result of extended

investigations with various chemicals. A triethanolamine oleate-petroleum oil mixture appeared promising, provided a certain amount of zinc sulphate was added.

The addition of bentonite clay as a spreader and sticker increased the effectiveness of lead arsenate sprays used in experiments conducted by the New Mexico Station for the control of codling moth. In bait-trapping studies ethyl oxyhydrate prepared by the esterification of vinegar proved highly attractive to adult moths.

In tests of three new materials, namely, coal-tar distillate, water-gas tar distillate, and dinitro-orthocresol for the control of rosy apple aphid, the Virginia Station found all three equally effective for the destruction of the eggs, but the tar distillates were considered preferable because of lower cost, greater availability, and less hazard to human beings.

Tar acid oils were found by the Ohio Station to be effective in the control of apple aphids. Apple flea weevils were controlled successfully by a combination of fluorine and flotation sulphur.

Tent caterpillars with a wide variety of hosts, including orchard and forest species, were found by the Connecticut (State) Station to be satisfactorily controlled by various measures, including the destruction of egg clusters, removal of the nests, and spraying with lead arsenate. Natural controls included parasites, a bacterial disease, and birds.

Dusts distributed from an Autogiro were observed by the New Jersey Station to be more effective than sprays from the ground in the control of canker worms.

Parasites were effectively employed by the Virginia Station for reducing the infestation of oriental peach moth and apple leafhopper.

Injury to peaches resulting from the application of arsenicals was overcome by the North Carolina Station by the inclusion of zinc sulphate and lime in the spray.

The Illinois Station also obtained favorable results from including zinc sulphate in arsenical sprays applied to the peach. For the control of the oriental peach moth the Illinois Station recommends that apples and peaches be planted separately and as a spray suggests a mixture of summer oil and nicotine sulphate.

Satisfactory control of various Lepidoptera, known collectively as orange worms, was secured by the California Station from applications of fluorine materials. The indications were that cryolite and barium fluosilicate may be combined with oil spray mixtures designed for the control of scale insects and red mites and also with certain other commonly used materials, such as sulphur dust and zinc oxide. Among new spray chemicals employed with considerable success by the California Station for the control of red mite, one of the major pests in southern California, were a compound of selenium and also dinitroorthocyclohexylphenol, the latter used in connection with a petroleum oil spray.

According to the Florida Station, ladybeetles of the genus *Leis* have proved useful in the control of citrus aphids.

Derris and cube root were found effective by the New York State Station in the control of the gooseberry fruitworm.

Observations upon different brands of calcium arsenate led the New York State Station to conclude that considerable variation

exists in commercial materials and that calcium arsenate sprays which will not injure the foliage are fully possible. Because of the absence of lead, calcium arsenate would be safer from the standpoint of spray residues. A method of determining the relative safeness of calcium arsenate with reference to foliage injury was devised by the station.

Soybean flour and soybean oil were found by the Illinois Station to be useful in orchard spraying, the flour as a spreading and sticking agent and the oil as an ovicide for the destruction of codling moth eggs and also for general use as a sticker. The wide use of these materials in spraying operations would afford a new outlet for soybean products as well as increase the efficiency of spray practices.

The addition of lime to lead arsenate sprays was found useful by the New Jersey Station in preventing spray injury resulting from lead arsenate applied alone. Sometimes the spray injury did not appear until several weeks following application and was apparently prevented by subsequent lime and lead arsenate sprays.

The accumulation of readily soluble arsenic in the surface 6 inches of soil as the result of long-continued spraying with lead arsenate is believed by the Washington Station to be one of the principal causes of crop failure following the removal of old apple trees and one of the difficulties in obtaining good stands of cover crops in existing orchards.

Arsenical poisoning of honeybees is a serious and increasing problem, according to the New Jersey Station, because of the greater use of arsenical dusts and the increased planting of sweetclover as a cover crop in the orchards. Insufficient rains to wash off the dust enhance this hazard in dry periods.

Spray-residue removal, an indirect result of the heavy spraying and dusting programs required to control insects, particularly the codling moth, occupied the attention of several stations during the year.

Hydrochloric acid solution was found by the Virginia Station to be considerably more efficient than sodium silicate in removing lead, arsenic, and fluorine residues. Bordeaux mixture when used with lead arsenate facilitated removal, whereas oils increased the difficulty. Wetting agents increased the efficiency of heated acid solutions but contributed little or nothing to unheated solutions in which the fruit remained one minute or less.

Observations by the New York (Cornell) Station indicated that flotation-type washers cause less bruising to apples than do underbrush types. Driers with the walk-over or shuffleboard type of conveyor increased the percentage of bruising, and chain sizers and conveyors were found responsible for much injury to tender varieties, such as Wealthy, McIntosh, and Oldenburg.

Both the Illinois and Pennsylvania Stations made important contributions to the design and construction of effective washing equipment, and several of the stations made extensive studies of various materials, such as nicotine, pyrethrum, rotenone, and phenothiazine, as possible substitutes for lead arsenate in the hope of eliminating toxic residues and thus obviating the need of washers.

In attempts to select and breed high-pyrethrin strains of pyrethrum the Tennessee Station found notable differences between

different strains in their content of pyrethrin in the air-dried blossoms. Since it was found feasible to propagate plants by division, it was possible to maintain these high-producing strains without diminution of their pyrethrin content. Crown division was found to be the most practicable of asexual methods.

The rust mite, one of the most difficult pests to control in citrus growing, was found by the Texas Station to be effectively and economically controlled by sulphur dust applied when three-fourths of the petals had fallen and when the temperature was 75° F. or more. A 2-percent solution of lime-sulphur was safely used in the spring and a 1.5-percent solution in the summer.

Insects were found by the California Station to make definite responses to various colored lights, and in some species the two sexes reacted differently to any given color. Working in cooperation with the State Committee on the Relation of Electricity to Agriculture, the station investigated the possibility of controlling insects by the use of colored lights to which was attached a device for electrocuting the insects. Marked success was secured in artichoke fields in reducing the percentage of worminess due to the plume moth.

Protection against diseases.—Fire blight continued to be one of the most difficult plant diseases with which apple and pear growers had to contend. The cutting out of cankers was advised by the Ohio Station wherever possible, but when too large, treatment with zinc chloride solution in late winter or early spring was suggested. It is suggested that the zinc chloride solution may be applied with considerable rapidity with a paint brush to the canker and adjacent tissues.

Further studies by the Arkansas Station on fire blight control confirmed the value of applications of a 1–3–50 bordeaux mixture as a cluster-bud spray, when 20 percent of the blooms were open, when 75 percent were open, as a calyx spray, and finally as the first cover spray.

The favorable effects of bordeaux mixture in reducing fire blight injury were observed also by the South Carolina Station.

That the composition of the sap of the apple tree may have an important bearing on the development and spread of fire blight was reported by the New Jersey Station. The results of studies showed that the addition to the culture medium of sap from a tree in susceptible condition favored the growth of the fire blight bacteria, while sap from trees in a resistant condition retarded their growth.

Investigations by the New York (Cornell) Station showed that the fire blight organism does not overwinter in the beehive or in association with the honeybee. However, it was established that honeybees may transfer fire blight from the hive to the flowers and from flower to flower, provided the insects have been feeding on blight-infested material.

Apple trees sprayed with bordeaux mixture were observed by the Virginia Station to retain fully 90 percent of their foliage at harvest time, whereas those sprayed with arsenate of lead alone or combined with certain sulphur materials lost much of their foliage. Nicotine bentonite, as an arsenate of lead substitute, had a favorable effect on the leaves, but its efficiency as an insecticide was not fully established.

In surveying the possible cause of mortality in apple orchards the Tennessee Station found a definite correlation between losses and presence of crown gall, woolly aphids, and hairy root, suggesting the advisability of fumigation or disinfection of the nursery trees. Believing that black root rot in apple trees may also be introduced into the orchard on the young stock, the station suggested a combination treatment of steam and formaldehyde.

The pimply rough bark condition of apple trees known as measles may be one of several troubles, according to the West Virginia Station. One type found associated with a specific parasitic fungus is designated as black pox, a second form occurring as the destructive bark disease of the Delicious apple is designated as internal bark necrosis, and a third, characterized by a superficial reddish bark rash, is given the original name of measles.

The Virginia Station distinguished two types of measles, namely, target spot, particularly injurious to Delicious apples, and true measles, occurring on York Imperial, King David, and Ben Davis. To date the only promising control measures lie in stimulating vigorous growth of the trees by fertilizers and cultivation. There was no evidence that pruning was of any permanent value in control.

The observations of the Virginia Station on apple measles were corroborated by the New Mexico Station, which found that apple trees in an unthrifty condition were predisposed to the disease.

Progress in the development of new fungicides was reported by the Delaware Station with the patenting of a new synthetic material known as copper zeolite recommended for use as a substitute for bordeaux mixture in spraying apples and other plants.

A serious physiological trouble of pears known as black end, found by the California Station to be associated with the type of rootstock, was controlled by inarching mature trees with young *Pyrus communis* roots.

That the plum tree is a factor in the prevalence of yellows and little peach diseases of the peach was reported by the Delaware Station, with the discovery that the insect carriers of these virus diseases breed profusely in plum trees.

Both bordeaux mixture and lime-sulphur were found by the Wisconsin Station to be valuable in the control of leaf spot, the most important disease of the cherry in that State. In severe outbreaks of the trouble the bordeaux mixture was the more effective, and a program including three applications was recommended for Montmorency and Early Richmond orchards.

Notable progress in the control of several citrus diseases was achieved by the Florida Station. The application of 2 pounds of copper sulphate eliminated practically all symptoms of dieback in orange trees and increased greatly the yield of fruit. The frenching disease of citrus was overcome by applications of zinc sulphate, and excellent control of melanose was obtained with a 1.5–1.5–50 bordeaux mixture. The treatment directly after picking of citrus fruits with 95-percent alcohol and sealing with shellac gave good control of the stem-end rot during storage. Paper wrappers impregnated with iodine and copper sulphate decreased decay but increased the pitting of the rinds.

Pursuing further successful studies on the role of zinc in overcoming certain physiological troubles, the addition of this element to the

culture medium was found by the California Station effectively to prevent symptoms similar to the little leaf disease in apricot, tobacco, squash, corn, tomato, sunflower, and cotton. Commercial sheep manure was markedly effective in preventing injury to all the species growing in toxic soil except corn, but it was not possible to explain the beneficial action of the sheep manure merely on the basis of zinc content. Further studies of mottle leaf disease of citrus led to the conclusion that zinc materials are specific remedies for this trouble. Spraying with zinc compounds was more effective than dusting with the same materials.

Studies in various States of virus diseases of raspberries led to satisfactory methods of control.

Careful roguing of diseased raspberry plants was found by the Washington Station to reduce greatly the hazards of rapid spread, particularly if clean stock was planted and the less susceptible varieties were grown. Mosaic disease spread more rapidly among black than among red varieties.

Despite the fact that the Columbian purple raspberry suffers little from mild mosaic, the New York State Station observed that this variety is a distinct menace to nearby black or red raspberries and recommends the isolation of the Columbian variety.

Practical control suggestions from the Ohio Station included the isolation of plantations from virus sources, such as wild brambles, and the frequent inspection and prompt roguing of plantings. The digging out of nonvigorous plants is urged even if they show no typical symptoms.

Vaporization, secured by passing sulphur sprays through heated coils at a pressure of about 125 pounds, was found by the Ohio Station to yield an effective fungicidal material, which, with the addition of a protective colloid, remained in a toxic state for several days. With vaporization only about one-fourth the amount of material was required that is ordinarily used in power spraying. The station developed a formula for home-made sulphur sprays composed of sulphur, a wetting agent, and gelatine, which are said to adhere better and to be less expensive and more effective than commercial materials.

The tendency for lime-sulphur-lead arsenate combinations to burn foliage was overcome by the Delaware Station by adding 4 pounds of a so-called catalytic sulphur to very 100 gallons of spray.

Physiological studies.—The Golden Delicious apple was found by the Missouri Station to equal Jonathan as a pollinizer for other apples. No commercial variety grown in Missouri, however, was found sufficiently self-fruitful to be planted in isolated blocks.

That pollen collected by honeybees and carried into the hive is either removed very quickly from the bees or else is rendered impotent was indicated in studies by the New Hampshire Station where hives which had been in the open orchard were moved into cages enclosing McIntosh trees. There was some improvement in set of fruit following the introduction of the bees, but the seed content was only slightly more than with self-pollination and less than half that of open-pollinated fruits.

Under Michigan conditions all the named varieties of highbush blueberry under trial were self-fruitful and yielded as satisfactory

sets as were secured by open pollination. The bumblebee was found to be the most important pollinating insect, and the pistils were observed to remain receptive for several days.

Loose and imperfect clusters of grapes may be largely eliminated, according to the New York State Station, by interplanting good pollen-producing varieties among the less favored kinds. The distance between varieties should not be more than 16 feet, and where the direction of the prevailing wind is known the pollinizing varieties should be located to the windward side.

Stating that the vanilla flower is so constituted botanically that self-fertilization is impossible and that in the native habitat flowers are pollinated by small bees and by certain kinds of hummingbirds, the Puerto Rico Station reports that in established plantations artificial pollination must be resorted to in order to assure full crops. As a result of the studies, the station published instructions regarding the best methods of pollinating vanilla grown in plantation form.

Working in cooperation with the Department of Agriculture, the Maryland Station found that the leaf surface per strawberry plant in autumn determines to a large extent fruit-bud formation and fruiting the next spring. Practical suggestions were given growers with regard to fertilizers and cultural conditions that encourage leaf development in the autumn.

From a study of measurements of leaves and fruits of apples the Missouri Station found a good correlation between the weight of fruit and of seeds and between the weight of fruit and weight of the spur leaves. There was no correlation between leaf weight and seed number, although the leaf area seemed to be related somewhat to the average weight and nitrogen content of the seeds.

The cracking of mature Stayman Winesap and York Imperial apples was observed by the West Virginia Station to be associated with unfavorable weather and moisture conditions. Generally cracking was initiated in some malformation, such as russeting, scab lesions, or sun scald, and sometimes in places of unusual coloration. Scanty foliage tended toward cracking, possibly because of the greater incidence of sun scald and other unusual conditions.

Cracking of sweet cherry fruits, which occurs when heavy rains fall during the harvest period, is due, according to the New York State Station, to the swelling of the flesh and may be roughly correlated with the firmness of the fruit.

Shading of grapevines was found by the Kansas Station to be helpful both to the vine and to the fruit under conditions of drought. Shading gave as good results as irrigation without shade and led to the conclusion that the wilting of leaves may be due to high transpiration and intense insolation rather than merely a deficiency of available soil moisture. Apparently under intense conditions the water-conducting tissues were not able to supply water rapidly enough to the leaves.

The uneven ripening of Concord grapes, a serious factor in some sections of the country, was found by the Oklahoma Station to be preventable in part by any practice which conserved the foliage and thus protected the fruit from hot sun and low humidity. On the other hand, practices which reduced or restricted the leaf area tended invariably to increase the number of green berries at harvest time.

Chemical tests showed that the sugar content of the berries had a definite relation to color and that 7 percent or more of sugar is necessary for proper ripening.

That the condition of the twigs has an important bearing on the resistance of the fruit buds to winter-killing was shown in studies conducted by the New Jersey Station. Thin twigs had a lighter fruit-bud set than thick twigs of the same length. As a result of the observations the station suggests that growers follow cultural practices which favor the development of strong fruiting twigs and enumerates various factors, such as spraying, insect or fungus injury, improper pruning, and deficiencies in nutrients, which may contribute to thin twigs. The partial disbudding of spurs was found by the New Jersey Station to improve the size and market quality of Wealthy apples. However, the cost of thinning is said to be a vital consideration, making important the development of more rapid and more practical methods for general use.

At the Virginia Station significant relationships were obtained between terminal shoot growth of York Imperial apples and production. In general the longer the growth the larger the number of apples and probably the smaller the size.

Repeated observations throughout the winter on the fruit buds of several varieties of peach led the West Virginia Station to conclude that the rate of temperature decline is extremely important in relation to injury. A minimum of −16° F. in January killed the buds of all varieties. Apple buds were badly injured at −32°, but a few survived.

Handling and storage of fruit.—The desirability under certain conditions of holding apples at moderate temperatures for a short period between harvesting and cold storage was indicated in studies conducted by the New Hampshire Station. McIntosh fruits held 5 days at 60°–65° before storing at 32° were lower in acidity, of better ground color, and in some seasons showed less tendency toward brown core. Each variety appeared to have a rather definite storage life within which quality could be maintained. The location of the orchard was a consistent but not significant factor in the keeping of Baldwin apples.

The coating of apples and pears with wax was found by the California Station to retard respiration and to delay ripening at 67°. Waxed Yellow Newtown apples were still green and marketable after 23 days, whereas normal fruits were fully yellow in about 17 days.

A study by the Minnesota Station of different types of packages for fruits, and of methods of packing, indicated that transparent wrappers might be of advantage to berries but that the present cost of such material raised the question of practical use.

Tree-ripened peaches, that is, fruits that had softened slightly along the suture line, were found by the Washington Station to keep in good condition for from 30 to 60 days when stored at from 32° to 35°. One day at 70° caused as much ripening as 2 weeks at from 32° to 35°.

The New Jersey Station assisted peach growers by devising a mechanical tester for determining the ripeness of peaches.

Adequate ventilation of the container was found by the Indiana Station to be an important factor in the precooling of peaches and led to the suggestion that the present baskets, pads, and paper liners

need redesigning so as to permit freer circulation of the air within the package.

Freezing storage of fruits and vegetables is a rapidly developing enterprise that interests several of the stations. From experiments with various fruits and vegetables the Oregon Station concluded that a temperature range of −5° F. to 10° was satisfactory for materials in small containers, but a constant temperature of 0° is considered highly desirable. (See also p. 136.)

At the Minnesota Station it was found that whole, diced, or crushed muskmelons and watermelons may be kept for 8 months at 0° without serious loss of quality.

The Sunbeam peach, originated by the New Jersey Station, was observed by the New York State Station to retain its yellow flesh color very well when the flesh was exposed to the air. This retention of color was believed due to the fact that the Sunbeam peach contained less of a tanninlike substance associated with discoloration than did other varieties.

In order to present fruit to the consumer in the best possible condition, the Oregon Station worked out an effective method of handling Bosc pears on their arrival in eastern markets. After unloading from the car the pears were held for from 4 to 7 days in insulated ripening rooms at a warm temperature to develop full flavor and attractive appearance.

The use of ethylene in hastening ripening of fruits and vegetables was defended by the Minnesota Station on the basis that ethylene is a natural product of certain maturing plants and fruits. In the case of red varieties of tomato it was found necessary to keep the temperature below 85° F. in order to permit the development of red pigments. The importance of keeping storage rooms and bins clean and of removing rotted products was stressed by the station as a means of overcoming objectionable flavors in stored fruits and vegetables.

Still-air storage was found by the Florida Station to be more desirable than circulating air for holding citrus fruits. At 37.5° F. the losses in weight and from physiological break-down were less in the still air.

The possibility of keeping black walnut kernels in good condition for considerable periods was shown as a result of studies by the West Virginia Station in which kernels were kept satisfactorily for 2 years when held in an atmosphere of nitrogen at temperatures near the freezing point. Vacuum, hydrogen, and carbon dioxide used under similar conditions likewise delayed the development of rancidity but were not equal to nitrogen. Storage in sealed containers was superior to storage in screw-cap jars, particularly at ordinary cellar temperatures, where considerable fluctuation in temperature occurs.

Fruit byproducts.—Immature apples removed from the trees during fruit-thinning operations were found by the Washington Station to contain abundant pectin recoverable by relatively simple methods of extraction. In preparation for extraction sliced fruits were held at room temperature in a 0.5-percent hydrochloric acid solution for from 2 to 3 days. Freezing also gave favorable results in preparing material for pressing. The pectin secured by hydrochloric acid extraction was of such a desirable color that charcoal clarification was unnecessary in the preparation of pectin for jelly making. Ripe

apples were found to contain considerable amounts of levulose, one of the sweetest of the sugars.

The removal by diastatic hydrolysis of the starch from pectic liquor and apple pomace was found in studies by the Delaware Station to result in a better and less expensive product.

The red coloring matter in the skins of Winesap apples was isolated by the West Virginia Station in pure form and found to be idaein chloride, an anthocyanin pigment similar to that in the cranberry. A glucoside was obtained in pure form as the chloride salt. With the knowledge secured it was hoped to develop methods of influencing pigmentation of fruits while still on the tree.

The pasteurization of Concord grape juice at 165° F. was found by the New York State Station to be adequate to kill all organisms in the juice and at the same time to cause less changes in flavor than resulted from higher temperatures. The elimination of all air from the bottles in which the juice was stored resulted in a reduced oxidation and a better maintenance of quality.

In chemical analyses of well-filled and poorly filled pecan nuts the Arizona Station found that the well-filled nuts have the highest oil content and the least nitrogen. Nuts from low-vegetative trees were best filled and showed less preharvest germination than did those from trees of more vigorous growth.

Interesting observations were made by the New Jersey Station on different methods of harvesting cranberries. For example, in hand picking only 4.4 percent of the berries were dropped and lost, whereas in scooping from a kneeling and a standing position 14 and 21.5 percent, respectively, were lost.

VEGETABLE GROWING

The breeding of new and better varieties.—As in the last few years, marked progress was made by several of the State experiment stations in the development of varieties of vegetables of higher quality or possessing resistance to diseases or to other unfavorable conditions. Observing the increase in mosaic diseases of beans, particularly in relation to the production of snap beans for canning purposes, the New York State Station, after experimenting with various means of control, reached the conclusion that the breeding of resistant varieties was the logical approach to solving the problem. Reciprocal crosses were made between the susceptible Stringless Green Pod Refugee variety, the principal canning variety now in use, and the immune Robust bean. The seedlings when backcrossed to the better quality parent yielded some new hybrids possessing immunity to mosaic and also many of the desirable characteristics of the Refugee variety.

Studies by the Idaho Station of a new mosaic-resistant Stringless Green Pod Refugee bean originated by the Idaho and Connecticut (Storrs) Stations led to the observation that the new variety possesses all the good qualities of the Stringless Green Pod Refugee parent. In addition the resistant strain ripens from a week to 10 days earlier and is well adapted to the Idaho climate.

At the Michigan Station several selections of late garden beans showing marked resistance to mosaic were being carefully studied as to their possibilities in commercial production.

The successful production of black-eyed beans in California threatened by *Fusarium* wilt disease was greatly favored by the development at the California Station of a strain resistant to this wilt. The new variety, named Calva, is being distributed to growers.

Progress was made by the South Carolina Station in the development of early-maturing stringless snap beans by crossing the ordinary commercial varieties with those of unusual earliness. However, none of the new seedlings ripened earlier than their early-maturing parent.

Golden Cross Bantam, a hybrid sweet corn originated by the Indiana Station and the Department of Agriculture, was reported by the New York State Station to be superior to any other variety tested in quality, yield, attractiveness, and in many cases with respect to wilt resistance.

Continuing its intensive program in the breeding of new varieties of sweet corn adapted to the Southwest, the Texas Station reported that the varieties Honey June and Surecropper Sugar developed by the station are proving valuable over a wide area. The Honey June variety was found moderately resistant to earworm attack, and another variety, known as Mexican June, was highly resistant.

In corn-breeding studies the California Station found evidence that resistance to earworm in sweet corn is a heritable characteristic and suggested that the production of hybrids of high quality and resistant to the earworm is feasible.

Marked progress was made by the Puerto Rico Station in the breeding of sweet corn varieties adaptable to tropical culture. Shipments of the new corn sold at very favorable prices on the New York market, and were pronounced as of very satisfactory quality and to compare very favorably with corn shipped from southern portions of the United States.

As a result of extended studies, the Minnesota Station reported the successful development of varieties of muskmelon which show marked resistance to *Fusarium* wilt and indicated substantial progress in the development of market varieties.

Crossing an inedible wilt-resistant watermelon obtained from the Union of Soviet Socialist Republics with the Early Fordhook, a commercial variety of good quality but susceptible to wilt, the West Virginia Station found definite indications that resistance to the disease is an inherited characteristic. The work was, however, in too preliminary a stage to indicate final results in the way of better varieties.

A variety of watermelon highly resistant to *Fusarium* wilt was developed by the Florida Station and distributed to growers under the name of Leesburg. A new squash secured from Africa and found valuable for table use as well as for forage was distributed by the Florida Station in the belief that it would be well adapted to Florida environment and also be free from insect and disease attack.

Continuing its activities in the breeding of spinach, the Virginia Truck Station reported the development of a new mosaic-resistant variety that will soon be distributed to commercial growers for trial. The parents of the new seedling are Virginia Savoy, originated at the station, and Nobel, a late-seeding variety. The new variety showed marked resistance to mosaic disease and to low temperatures

and is said to be particularly well adapted to planting in the late autumn for the early spring crop.

Marked progress was made by the Massachusetts Station in the breeding of tomatoes resistant to leaf mold caused by the fungus *Cladosporium fulgum*. So promising were certain of the seedlings that the station released seed to other experiment station workers in various parts of the country for trial and report. Various seedlings combined resistance to the mold fungus with desirable size and market characteristics.

Improved cultural practices.—Perhaps the most significant development in recent years along strictly cultural lines has been the work in the more efficient placement of fertilizers for various vegetable crops. As a result of these studies, conducted cooperatively by the Department and several of the State stations, it was found that considerably smaller quantities of fertilizer, properly placed, produce large crops at material savings. In addition the proper placement of fertilizers reduced the injury to seed and young plants of certain species.

In studies carried on by the Virginia Truck Station the astonishing increase of 2,600 percent was recorded in the germination of kale where the fertilizer was placed in bands on each side of the row as compared with germination where the fertilizer was placed in a single band 1 inch below the seed. With other crops, such as beans, peas, and spinach, it was observed that the fertilizer applied directly in contact with, or 1 or 2 inches below, the seed greatly reduced germination and resulted in poor stands and low yields.

Similar experiments conducted by the New York State Station indicated that the manner of placement of the fertilizer must be correlated with the type of fertilizer used. Some fertilizers when placed in bands close to the row or in contact with the seed were found exceedingly injurious, while others had little or no effect. Moderate applications carefully placed along the row were found to give better results than heavy applications because of the reduced concentration of chemicals near the living plant tissues. With nonfertilized beans averaging 36 bushels per acre at the first harvest, placement of fertilizer in bands on each side of the row at different rates greatly increased the yields. The rows that were fertilized by the band method of application set more pods than did the checks or those where the fertilizer was broadcast.

The feasibility of replacing part of the stable manure used in truck-crop fertilization with commercial fertilizer was indicated in experiments conducted by the Illinois Station with 10 major vegetables over an 8-year period. When half the stable manure was replaced by commercial fertilizers the yields were even larger than with the full manure treatment alone. In the absence of stable manure complete commercial fertilizers were more effective than those lacking in any constituents.

Pure sand with organic salts added in solution was found by the Connecticut (State) Station to be a desirable medium in which to grow many different species of seedlings. Under such conditions much of the trouble from damping-off was eliminated, and most of the seedlings were found to grow readily and to develop normally up to the stage of transplanting into the field.

In its investigations of the fertilizer and cultural requirements of vegetables the Virginia Truck Station successfully employed sap tests for determining the nutrient needs of various vegetable plants and proposed certain modifications of the rapid chemical test for phosphorus requirements.

Continuing comparative tests of electricity, coal, gas, kerosene, and farm manures as source of heat for hotbeds, the Pennsylvania Station found that coal heaters were the most uniform in performance and were somewhat more economical in operation than the other sources of heat. In general, germination was more rapid and the seedlings appeared earlier above ground when the heat was applied below the soil rather than above. The manure-heated beds were particularly successful in the production of plants of sturdy growth habits; for example, tomatoes produced in the manure-heated bed weighed nearly twice as much per plant as those in other beds at the time of transplanting to the field.

That electricity may be used economically as a source of heat for hotbeds was indicated in experiments carried on by the Kansas Station, in which it was shown that, if careful consideration was given to the insulation of beds and the use of protective mats during cold nights, electrically heated beds could be operated at only slightly greater cost than those heated by the burning of wood. The plants were much alike in both quantity and quality.

In accord with findings at certain of the stations that soils may be deficient in other than the three major elements, namely, nitrogen, phosphorus, and potash, the Virginia Truck Station found that local truck soils may be deficient in magnesium to the detriment of crops grown thereon. The station recommended the use of dolomitic limestone in connection with all mixed fertilizers not only to keep the soil at the proper reaction but also to supply the indicated magnesium deficiency. The desirability of plowing under a cover crop once every 2 years or oftener was also indicated. The more important truck crops grown in the vicinity of Norfolk were classified with reference to their reaction to magnesium deficiency and their response to dolomitic limestone. There was some indication that, from the standpoint of magnesium nutrition, relatively large amounts of sodium salts should not be used in combination with magnesium salts. The need of a fairly well-balanced fertilizer was suggested. Certain crops, such as cabbage, peppers, cucumbers, and tomatoes, responded to the application of water-soluble magnesium applied at the rate of from 20 to 40 pounds of magnesium oxide per acre in the fertilizer used as a side dressing. When neutral salt mixtures and magnesium limestone of from 80- to 100-mesh fineness were used the soil reaction was maintained fairly constantly against any change resulting from the use of acid-forming fertilizers.

At the Arkansas Station there was found to result a very definite decrease in production for any increase in acidity below pH 7 for practically all vegetable crops, and approximately the same production was obtained at pH 7 and at pH 8. Muskmelons were outstanding in their response to applications of lime on soils of a reaction of pH 5.5 to 6.5. The application of large amounts of acid-forming fertilizer to spinach growing on a soil with the initial reaction at approximately the lower range for satisfactory growth so increased

the acidity of soil at the Virginia Truck Station that the yields were reduced to approximately one-third of those secured when a nonacid-forming fertilizer was used.

As a result of extended cutting experiments with asparagus, the Louisiana Station concluded that the fall harvesting of asparagus cannot be recommended. On the whole the production of asparagus was so limited that the crop is recommended only for local use, that is, for the production of material for home consumption or possibly for local markets.

Under Iowa conditions cutting of asparagus until July 15 each year was found by the station to be a poor practice, materially shortening the profitable life of the plantation. In fact the quality of the spears after 5 years of prolonged cutting was so poor as to render the plantings unprofitable. Cutting until June 15 appeared to give the best results under the conditions of the experiment. Rows spaced 5 feet apart produced more spears and more total weight of asparagus than did lesser distances. Plants cut until June 15 the second year after setting in the soil produced smaller yields in subsequent years than did plants which were not cut at all until the third season. One-year transplants were the most desirable for the establishment of plantations.

Observations by the New Jersey Station on a number of farms indicated a marked advantage from liming beans and that the dolomitic forms of limestone are now being much more freely used than in past years.

In long-continued studies of the fertilizer requirements of early cabbage the New Mexico Station found that stable manure is an excellent fertilizer but that manure supplemented with ammonium sulphate gave more profitable returns than manure alone.

That phosphorus may often be a limiting factor in cabbage production in certain parts of Virginia was shown in studies conducted by the Virginia Truck Station in Wythe County. The soils of the area were apparently fairly well supplied with potash, yet the application of potash in the fertilizer increased yields. Particularly favorable results were secured with a 4–8–12 mixture applied at the rate of 1,000 pounds per acre. On the more fertile fields, where stable manure had been applied liberally or leguminous crops turned under, a lower content of nitrogen in the mixed fertilizer gave satisfactory responses, especially when a supplementary side dressing of nitrate of soda was applied later in the growing season.

That the use of plant protectors in the growing of cantaloups is justified when a premium for earliness is assured was indicated in experiments conducted by the Arkansas Station. All the different types of protectors tested stimulated germination and protected the young cantaloups from rodents, insects, and weather hazards. The plants grew more rapidly beneath the protectors but as a rule suffered a temporary check when the covers were removed. However, usually the plants exhibited marked ability to readjust themselves to changed environment and to resume development in a short time after being uncovered.

That the color of carrots may be affected by the type of culture employed was indicated in studies conducted by the Louisiana Station. In these experiments better-colored roots were obtained when

carrots were grown on raised beds, it being apparent that aeration of the soil was an important factor in the development of a desirable color of the roots. On the other hand, fertilizers and soil reaction had no significant bearing on root color.

In attempts by the New Mexico Station to build up a vegetable seed-producing industry it was found that satisfactory crops of carrots, celery, and cabbage seed may be produced in that State. Of various fertilizers tested by the station for the growing of commercial onions a complete chemical mixture supplementing 10 tons of stable manure to the acre gave the highest total profit per acre. The investment, however, was high, making the risk from possible crop failure or price reductions out of proportion to the risk and profit from some of the other treatments employed.

In studies of onion production the Michigan Station found that the muck soils were on the whole ideal for the production of onions, being usually well supplied with moisture, easily cultivated, and relatively loose, so that the bulbs may adjust themselves with less need for thinning. With a good system of soil management onions may be grown almost continuously on the same soil for many years without appreciable decrease in yield. A definite correlation was shown between the soil reaction of the muck and its adaptability to the onion crop.

Definite indications were secured by the New York (Cornell) Station that the fertilizer program for onions on muck lands must be altered according to the length of time the fields have been under cultivation. Among valuable findings in the study was the fact that applications of finely ground copper sulphate, 300 pounds per acre, were of great benefit on muck soils that produced onions with thin, poorly colored scales and on which the tops died prematurely. Copper sulphate was applied either singly or mixed with the general fertilizer.

The close relation of temperature to the development of the onion was shown in studies carried on by the Montana Station. Transplants grown at fairly low temperatures, a minimum of 43° to 50° F., proved distinctly superior to those grown at high temperatures, 60° to 70°. The onions produced from the lower-temperature group were superior with respect to yield, maturity, and keeping quality. Field seeding, however, gave the best onions for winter storage. Transplants set 1.5 inches deep produced more doubles and flat onions and less round and elongated onions than did transplants set 3 inches deep.

Observing considerable injury to canning peas resulting from close contact of fertilizers with seed, the New York State Station devised an attachment to the seed drill so that the seed and fertilizer could be sown in one operation but without the fertilizer coming in actual contact with the seed. Three years' experiments with the new attachment proved it to be highly efficient. The addition of 1.5 ounces of graphite to a bushel of pea seed facilitated seeding with a drill and greatly reduced shattering and cracking of the seeds which may in some cases reach a maximum of 10 percent of the seed. The graphite treatment was found of particular value in the case of pea seed which had been dusted with red copper oxide.

The New York (Cornell) Station found that blue light was superior to red in inducing the flowering of lettuce plants. Red light stimulated flowering, but the plants were too weak to complete the process of seed formation. Comparatively low temperatures ranging from 50° to 68° F. were favorable to the reproductive growth of various plants.

Sweet corn treated with complete fertilizer containing superphosphate came into tassel at the Puerto Rico Station 16 days earlier than plants receiving no phosphoric acid. The yield of marketable ears increased by the use of a complete fertilizer containing phosphoric acid. In a comparison of ammonium sulphate and sodium nitrate for sweet corn the station found that ammonium sulphate applied at planting significantly increased the stand and marketable ears produced. Presumably ammonium sulphate stimulated early growth so that the corn plants soon attained a size where they were not seriously injured by mole crickets.

Observing that the cracking of tomato fruits causes serious losses to the growers in certain years, the Maryland Station investigated possible causes of this trouble and found that nitrogen, phosphorus, and potassium when applied in large amounts to the soil had no appreciable effect on the cracking of tomato fruits. Tomatoes growing on plants pruned to a single stem cracked more severely than did those on nonpruned plants. The indications were that the absorption of water by the fruit from either inside or outside the plant was the principal cause of cracking. The occurrence of corky spots or corky layers facilitated the entrance of water.

Where entire tomato plants were shaded, the Ohio Station observed a decrease in the severity of the cracking of the fruit. The severity and the degree of cracking increased with the stage of ripeness at which the fruit was harvested, and at none but the very immature stages were all the fruits entirely free from cracking.

The inadvisability of applying excessive quantities of nitrogen to tomato plants was indicated in studies by the Rhode Island Station, which showed a tendency for excessive nitrogen to decrease fleshiness of the fruits and thus impair their quality.

In trials of different combinations and amounts of fertilizers for tomatoes, the Maryland Station reached the conclusion that complete fertilizers high in phosphorus and potassium give the best results. Of single materials used, stable manure was the most satisfactory, with superphosphate next. Additional side dressings with complete fertilizer proved of no advantage as compared with a single application at the time of setting the plants in the field. Manganese sulphate gave only a slight yield increment and none of the fertilizer treatments had any material influence on the quality of the canned tomatoes.

A strongly acid reaction (pH 4.4 to 5), especially in soils of low organic matter content, was found by the Virginia Truck Station to greatly retard the growth of Marglobe tomato plants. The optimum development was obtained in soils with a pH of 5.5 to 6.4, but more nearly neutral reactions were not beneficial.

That much larger amounts of nitrate of soda may be required to maintain optimum yields of spring-grown tomatoes than of plants

set in the greenhouse in September was indicated in experiments conducted by the Rhode Island Station; in fact twice as much nitrate of soda may be required by the spring crop, but the yields were also much larger. As a result of the studies, the station points out that the economical use of nitrate of soda for greenhouse tomatoes may be expected to vary with the season of the year and also with the quality and quantity of the cow manure used.

The Pennsylvania Station has developed a simple method of growing uniform mushroom spawn on grain without the use of manure. In addition, more effective methods of combating disease and insect pests and of the use of compost as a substitute for manure have been developed.

Phosphatic fertilizers were found by the Montana Station to result in larger, stronger-rooted, and sturdier plants of various kinds of vegetables which could be transplanted effectively and which would mature in the field.

A popular circular was issued by the New York State Station on the culture and utilization of various herbs, such as dill, caraway, lavender, mint, rosemary, sage, and thyme.

Combating insect enemies.—The rapid spread of the Mexican bean beetle led to the study of methods of control by various States. A new and more effective form of cryolite, a fluosilicate preparation, was developed by the Tennessee Station. This new material was of a light, fluffy nature, being over twice as bulky as other cryolites and in addition remained longer in suspension, adhered unusually well to the leaves, and was harmless to the bean plants.

Cryolite was also found effective by the Maryland Station, which included in its recommendation for the control of the bean beetle the plowing under of crop remnants and a carefully prepared program of dusting and spraying.

In studies by the Iowa Station it was found that derris used either as a spray or dust was the most effective material for the control of the Mexican bean beetle but was a little too expensive. Cryolite and magnesium arsenate proved more effective as sprays than as dusts. Lead arsenate and calcium arsenate often seriously injured the bean plants. Derris is considered particularly valuable on account of its nonpoisonous qualities to man and the possibility of using the material after the pods have formed. The method of applying insecticides was found an important factor, and it was recommended that sprays or dust be applied to the under side of the leaves after the beetles have become numerous and are laying eggs.

The infestation of navy beans by the common bean weevil was found to be preventable by the Indiana Station by dusting the plants with various materials, such as clay and dusting talc. Hydrated lime proved a little less efficient but gave good results at all dilutions used. Coal ashes and wood ashes also gave satisfactory protection, and in general the protection offered by any of these nonpoisonous materials was directly correlated with their adhesiveness. None of the materials affected the cooking quality of the beans nor the germination.

In studies of the beet leafhopper the Utah Station found that various natural enemies, such as lizards, birds, and many different kinds

of insects, attacked this pest in its desert breeding areas and that in the beet fields the predacious bugs, *Nabis ferus* (L.) and *Geocoris decoratus* Uhl., are the two most frequent natural controls.

Derris and pyrethrum were found by the Michigan Station to be effective substitutes for more toxic materials in the control of insect pests of cabbage, cauliflower, and beans. It was recommended that pyrethrum dust to be effective for the control of insects such as those infesting celery should contain from 30 to 50 percent of finely ground pyrethrum or its equivalent pyrethrins mixed with some inert material.

Time of planting cabbage and cauliflower was observed by the New York State Station to be an important factor in protection against the cabbage maggot. As a rule late cabbage was seldom troubled by the maggot because the plants were not set out in the field until most of the flies had disappeared. Treatment of early cabbage plants with corrosive sublimate applied to the soil about the roots was found effective in controlling maggots if applied within from 3 to 5 days following transplanting. Calomel applied either in dust form or in suspension was also found an effective means of protection and appeared to be equally as effective as the more dangerous corrosive sublimate and at the same time cheaper and easier to apply. Good control of the cabbage maggot was secured by a single, or at most two, applications of a suspension of from 3 to 4 ounces of calomel in 10 gallons of water.

Three applications of derris dust at weekly or 10-day intervals gave excellent control of the diamondback moth on collards growing at the Virginia Truck Station. A single application failed to give effective control, due to the fact that the full-grown larvae are resistant to the dust and more frequent applications were needed to contact the worms in their earlier stages.

Nematodes in greenhouses used for the growing of cucumbers were found by the New Jersey Station to be effectively controlled by applications of carbon disulphide emulsion to the soil.

Severe infestations of onion maggots were controlled by the New York (Cornell) Station by the use of a calomel seed treatment. In observations on a large number of varieties there was some indication of varietal resistance to onion maggot, and it was an interesting coincidence that the same varieties also proved resistant to onion thrips.

In studies conducted in cooperation with the United States Department of Agriculture, the Idaho Station found that hibernating pea weevils living beneath the bark of ponderosa pines suffered severe killing when the outdoor temperature dropped to a minimum of −19° F. At the same temperature all the weevils in hibernation cages in unprotected places were killed.

Working with a large number of varieties of canning peas, the Wisconsin Station observed a relationship of foliage color to aphid resistance, varieties with yellow foliage being resistant to the aphid, while those with green foliage were susceptible. There was some indication that resistance and susceptibility are inherited with the yellow and green color, respectively.

Derris dust in laboratory and field tests conducted by the Alabama Station proved the most effective material yet used by the station for

the control of various vegetable insects, including the Mexican bean beetle, the cabbage worm, and the potato beetle. Derris was so satisfactory that it is almost entirely replacing the arsenicals used formerly for controlling garden pests in Alabama.

With certain crops red spiders in the greenhouse were controlled satisfactorily by the Massachusetts Station by vaporizing commercial flaked naphthalene. This method was successfully used for the begonia, calendula, carnation, cyclamen, and gardenia but could not be used safely with lilies, sweet peas, tomatoes, or cucumbers.

Some interesting results were secured by the New Jersey Station in the control of insects by electricity. By the rapid oscillation of an 8,000-volt current between two electrodes sufficient heat was generated to kill insects without injury to the host plants.

Protection against diseases.—In addition to studies upon the development of disease-resistant varieties covered under the head of vegetable breeding, considerable activity was also manifested in the control of diseases by the use of sprays and dusts and by supplying deficient nutrients.

An internal browning of cauliflower in sufficient amount to cause serious losses to growers in various parts of New York State was found by the New York (Cornell) Station to be associated with a lack of boron in the soil. The disease was first manifested as small water-soaked areas in the central portion of the stem and in the small branches of the flower head. Later rusty brown areas appeared on the surface, and this stage is known as brown or red rot. The heads were not only discolored but were also bitter to the taste and unmarketable. It was found that applications of not more than 5 pounds of borax to the acre effectively controlled the brown rot disease.

A program for the control of celery blight was developed by the Michigan Station as a result of extended studies. The seeds were first soaked for 30 minutes in lukewarm water and then placed for 30 minutes more in a 1:1,000 solution of corrosive sublimate. Following germination the seedlings were dusted 4 or 5 times in the seedbed and the plants dusted in the field at from 7- to 10-day intervals with copper materials. Since irrigation is a factor in blight injury, the station recommended that irrigation be done in the morning and under such conditions as favor the rapid drying of the foliage.

A virus disease of summer lettuce and endive, known popularly as yellows, was found by the New York (Cornell) Station to overwinter in certain weeds, the most common of which was the broad-leaved plantain. The eradication of such weeds in a limited area around the fields proved highly effective in reducing the amount of yellows on the summer crops. Spraying or broadcasting sodium chlorate in April was found to be the most satisfactory method of eradicating the weeds, and the treatment yielded a return of more than $4 for each dollar spent.

Greenhouse studies at the Idaho Station showed that the virus disease, which causes severe infestations of mosaic in field and garden peas, is identical with that causing mosaic on red and alsike clover. It was apparent therefore that these clovers are probably important overwintering hosts for the disease.

The treatment of spinach seed with a commercial zinc compound was found by the Virginia Truck Station to give a tremendous increase in stand with plantings in late August and good results with later plantings made in November. So successful was the treatment that growers are now urged to treat all spinach seed irrespective of the time of planting.

That bordeaux mixture may be actually harmful to young tomato plants was indicated in studies at the Ohio Station. Plants set immediately after spraying with bordeaux suffered high mortality, whereas those planted 5 days or more after spraying suffered little injury. The cause of the mortality was apparently a heavy loss of water induced by the bordeaux mixture.

Cooperating with several of the northern stations, including Delaware, in an effort to secure disease-free tomato plants for northern shipment, the Georgia Station found that a 5-minute immersion in a 1:3,000 mercuric chloride solution was an effective general treatment. Rotation of the soil used in growing tomatoes and spraying the plants with bordeaux mixture were also beneficial treatments.

Studies of the nature of wilt resistance in the watermelon plant and of possible modes of attack by the fungus led the Iowa Station to conclude that watermelons are liable to be attacked at all stages of development and indicated that the fungus enters the plant through the root tips and then breaks down the tissues of newly developed lateral roots. Resistant plants apparently withstood attacks of the disease such as would have proved fatal to seedlings. Environmental factors, such as changes in air and soil temperature and rainfall, affected the progress of wilting, and the varieties Pride of Muscatine, Iowa King, and Iowa Belle proved valuable sources of resistant seedlings.

A brief comment from the Texas Station reported that seeds from either infected watermelons or okra may act as carriers of *Fusarium* wilt.

In studies of sulphur fungicides the Delaware Station found that the fungicidal efficiency of elemental sulphur increases as the particle size decreases but only when the proper type and amount of wetting agents are used along with balanced physical dispersion of the particles with respect to filming.

The respiration rate of bean plants was found, in studies conducted by the Montana Station, to be increased by the application of poorly refined petroleum oils. The theory that oil films injure plants by closing the stomata was not borne out by these tests; instead it appeared that injury is due to toxic substances in the oil itself.

In a study of the reasons why Pacific coast vegetables are offering increased competition with fresh vegetables produced in the Eastern States, the New York (Cornell) Station found that better selection, handling, and precooling methods enabled western growers to put their vegetables on eastern markets in better condition than locally grown products. This was particularly true of fresh peas. It was observed that heating peas up to 100° F. or higher for a few hours caused far greater deterioration in quality than if they were held at 30° to 40° for the same number of days. A simple and effective program of precooling and storing peas, beans, celery, and other

vegetables was presented, and the wider use of such methods was urged.

In search of a method for determining the maturity of canned peas the New York State Station found that the amount of alcohol-insoluble solids contained in the peas was a satisfactory index to their maturity at time of canning. Canned peas of low quality or made from mature peas contained more than 23 percent of such solids. On the basis of the study the Food and Drug Administration of the Department outlined certain standards for canned peas.

Studies of the amount and character of the sugar in Klondike watermelons grown by the California Station showed percentages of sugar in the extracted juice ranging from 8.12 to 9.97 and increasing up to the forty-fifth day but not materially thereafter. In immature melons the percentage of monosaccharides was considerably higher than that of the disaccharides, but as the fruit approached maturity this ratio gradually reversed itself until in overripe fruits the disaccharide content was much higher than that of the monosaccharides.

ORNAMENTAL HORTICULTURE

Cultural investigations.—Working on the response to temperature of the China aster, the Indiana Station found that high temperatures may profoundly affect not only the time of flowering and the type of inflorescence but also may induce flowering despite unfavorable length of day. The response of the aster to temperature was opposite to that of the stock, wallflower, beet, cabbage, and celery, where high temperatures tend to inhibit blooming. Four new chrysanthemums particularly suited to Minnesota conditions were distributed by the station under the names of Hiawatha, North Star, Fawn, and Snowflake.

That the delphinium may be forced into blossom in November or December was shown in studies carried on by the Massachusetts Station with plants which had been held at temperatures between 32° and 38° F. for 8 weeks early in the summer. This period of low temperature was apparently necessary to induce flowering in plants which had already blossomed that year.

Flowers of the French marigold were held satisfactorily by the Iowa Station at 40° F. with better results than at 33°. The wrapping of blossoms in waxed paper was also helpful. Apparently the low internal pressure brought about by storing blooms without water slowed down maturity and increased the life of the flowers at room temperatures.

In winter-forcing experiments with gladiolus the Rhode Island Station found that fertilizers containing nitrogen tended to increase the corm weight, and supplementary lighting provided during the early growth of the plants greatly increased flower yields. Mazda lamps of 100-watt intensity were sufficient to stimulate flowering.

See also p. 179.

Employing the sand method of culture, in which nutrients are supplied in solution, the New Jersey Station grew poinsettias successfully in 4-inch pots. That species of shrubs and ornamental trees may vary widely in their response to lime and forms of nitrogen

fertilizer was indicated in experiments conducted by the Rhode Island Station. In some cases the growth of plants was greatly stimulated by lime and in others liming had a decidedly harmful effect. Some species responded more favorably to sodium nitrate than ammonium sulphate and vice versa. As a result of the studies a large number of species were classified with reference to their response to lime and soil reaction.

Control of diseases.—Black spot of roses, a serious trouble both in greenhouse and outdoor culture, was studied by the New York (Cornell) Station. Practically perfect control of the disease was secured in the greenhouse when the practice of syringing plants with water was eliminated. This kept the foliage dry and provided conditions unfavorable for the germination of the spores. This new method of culture was made possible through the development of a new proprietary compound toxic to the red spider mite hitherto controlled largely by syringing. Growers who followed the new program of rose culture reported very favorable results.

The bud drop of sweet peas grown under glass was found by the New Jersey Station to be a nutrient problem and could be reduced by the use of high-concentration nutrient solutions.

In control experiments carried on at the Mississippi Station it was found that a fluffy form of calomel used at the rate of 1 pound to about 10 quarts of water was efficient as a disinfectant against the scab disease of the gladiolus. Immersion of the corms for 12 hours in a 1:1,000 solution of bichloride of mercury was also found effective. Six applications of bordeaux mixture to the foliage greatly reduced the amount of foliage infection and the number of clean corms harvested at the end of the season but was not sufficiently effective to be used without corm treatment.

Observing that rhododendrons overwintered in the greenhouse suffered high mortality from wilt disease, whereas comparable plants left outdoors were in a healthy, vigorous condition the following spring, the New Jersey Station reports that the wilt-disease organism attacking rhododendrons cannot apparently overwinter in the soil under outdoor conditions.

The effect of light on plants.—Investigations at the New York (Cornell) Station with different colored lights indicated that red light was superior to blue in aiding flowering in certain short-day plants, such as asters and early-flowering cosmos, that are not extremely sensitive to the photoperiod. Blue light, however, did not completely inhibit flowering. Other short-day plants, such as salvia, chrysanthemum, and kalanchoe, were extremely sensitive to photoperiod and did not flower in any of the long-day exposures. It is believed that short-day plants are probably prevented from flowering in summer not only because of the long days but also because of the high intensity of blue light occurring at that season. On the other hand, long-day plants may not flower in winter not only because of the short days but also because of the low light intensity present at that time of year.

Regulating the day length for asters, the Ohio Station found that a reduction in the daylight period promoted earliness in all varieties. However, in most varieties reduction of the day resulted in slightly smaller flowers and in the instance of the Royal Shell Pink variety

the flowers were produced on such short stems as to be of little commercial value.

From several years' investigations, the Indiana Station concluded that the use of artificial light to supplement sunlight, especially during dark weather, may be an economical procedure but that the usual cultural practices with regard to fertilizers, watering, and disbudding may need to be modified somewhat when electric light is used in the greenhouse for plant forcing.

In using different types of lamps as sources of supplemental light for greenhouse plants, the Ohio Station found the ordinary Mazda lamp superior to either neon or mercury lamps not only in promoting earliness of bloom but also growth, flower production, stem length, and size of the blooms.

In light experiments with pansies, stocks, and China asters the Indiana Station found little difference in response of the plants to intensities varying between 100 and 10 footcandles. There was an increase over the control plants in dry weight in all three species under all the intensities of light used. Orange and red lights caused the most marked response in all three species.

See also p. 179.

FORESTRY

Improved silvicultural practices.—Working jointly with the Department of Agriculture, the Iowa Station found that the inoculation of black locust seeds was decidedly advantageous. The increase in total nitrogen content of the seedlings as a result of inoculation was approximately 300 percent on a soil of low fertility and 80 percent on a soil of rather high fertility. It was found that root-nodule bacteria of soybeans and *Dalea* were incapable of producing nodules on black locust roots and reciprocally that the black locust nodule bacteria were incapable of causing nodulation on the other legumes.

Continuing its long-time studies on thinning of pine plantations, the Vermont Station found that thinning results in definite changes in certain important physiological factors of the site and through these changes influences materially the growth of the trees. Among changes resulting from the thinning was an increase in soil temperature as a result of the increased sunlight reaching the forest floor and also an increase in available soil moisture during periods of low level.

The character of the site upon which trees were growing was found by the Arkansas Station to be correlated directly with their growth. The importance of a fair degree of drainage but with adequate water supply was shown, and in fact the quality of the site appeared to be more dependent on available water supply than any other one factor. The higher the site index of the soil the more and larger were the roots produced by the trees. Observations over a continuous period of 2 years on the root growth of seedlings of shortleaf and loblolly pines showed outbursts of more active root development occurring in early spring and again in late summer or early autumn. Periods of little growth characterized as semidormancy occurred from December to March and from June through August. In these cases lessened root growth was associated with low air temperature and low rainfall, respectively. However, in winter, when the temperature was

low, high rainfall had no accelerating effect on root growth. On the whole, sand was found to be the best medium in which to germinate and grow pines, provided an abundance of water was available. Large amounts of nutrients, particularly of nitrogen, did not yield favorable responses.

Control of pests.—A type of Chinese elm was discovered by the North Dakota Station, working cooperatively with the Department, which showed manifest resistance to Dutch elm disease. Since the Chinese elm is able to withstand very low winter temperatures, it is thought that this resistant type might be well adapted to planting in many northern regions.

Slime flux, a condition in which wounded portions of the tree are covered with a slimy, fermenting wet ooze, was studied by the New Mexico Station, and the results led to the recommendation that the most important step in preventing this trouble is to treat wounds before the exudation occurs with bichloride of mercury or copper sulphate.

For combating spruce gall the New York State Station found that spraying the under side and tips of all branches with a mixture of nicotine and fish-oil soap early in October was decidedly beneficial. A spray mixture made up of 1 pint of nicotine sulphate and 5 pounds of fish-oil soap dissolved in 100 gallons of water was suggested.

Development of new insecticides and fungicides and of methods of control.—Notable progress was made by the stations during the year in the development of new and improved spray and dust materials for the control of various insect and plant-disease pests. The studies in the development of substances effective in control of pests and at the same time nontoxic or less toxic than the usual materials to humans were particularly noteworthy and potentially of great significance.

J. W. Wellington.

ANIMAL PRODUCTION AND PRODUCTS

Scientific research has taken an increasingly important place in the field of animal production. With the change from extensive to intensive types of husbandry, it has become more and more important to have a scientific background for economical production. Such a background includes not only more and better information regarding the value and use by animals of various feeds, but knowledge of the reproductive and productive capacities of each kind of animal. It has also been necessary for the experiment stations to continue their research on methods of handling, processing, and manufacturing animal products in order to keep pace with the constant demand for new and improved commodities. Examples of the recent findings in such research are given in the following pages.

ANIMAL GENETICS AND PHYSIOLOGY

Progress in studying the mode of inheritance of characters in the larger farm animals is materially retarded by the slowness of reproduction and the high cost of maintenance in sufficient numbers to yield significant results. This situation is partly relieved by the

fact that principles of Mendelian inheritance already established by results obtained with plants, rodents, and insects are basically applicable to livestock. In their efforts to further unravel certain fundamental problems of heredity, experiment stations continue to conduct genetic studies with laboratory animals to determine the interrelationships of various inherited factors. Selection for less obvious characters may then be made through linkage with genetic factors for some easily observed character such as color.

The forms of the various organs of the animal body have been known for a long time, but some of their functions have not been clearly understood. In order to make the animal plastic enough so that man may regulate it to suit his needs it becomes necessary to know what function each organ plays in growth, production, and reproduction. Such research is fundamental in character and of a very technical nature. The results, however, are applicable in a very practical manner.

Genetic studies with laboratory animals.—The California Station described the occurrence of a second gene for curly type of hair in the rat which is indistinguishable in its expression from another gene which produced curly hair. In studying the combined effects of two genetic factors causing pinkeye in the house mouse, the Illinois Station found that a very light-colored coat resulted. It found further that one of the factors causing pinkeye was linked with the nonyellow factor in the house mouse. A recessive genetic factor causing the appearance of white hairs in the pigmented coats of guinea pigs was observed at the Iowa Station. This condition caused a characteristic described as "silvering" in guinea pigs of several different colors. The degree of silvering was affected by modifying factors. In other studies at the same station, a defective eye condition in guinea pigs ranging from a slight sensitiveness to light to dulling and drying of the cornea was found to be inherited as an incompletely recessive factor. Such conditions are analogous to abnormalities which may appear in livestock and are due to recessive genes.

Insects are especially suitable for studies where greater refinement in methods is required and large numbers are necessary to give significant results. The Kansas Station employed the grouse locust to demonstrate translocations in portions of chromosomes and their effect on the animal. These results showed that although individuals were markedly deficient in certain portions of chromosomes, they survived when additional chromosome material was attached to other chromosomes. The Missouri Station employing the fruitfly made further investigation of the factors influencing chromosomal segregation in translocations and showed that in a four-chromosome ring segregation occurs along a given axis in proportion to its relative paired length, but the distribution of the chromosomes tended to be at random.

Inherited morphological abnormalities.—A study was made at the California Station of the appearance of a semihairless condition in Jersey cattle in which calves had no hair below the knees or hocks, around the eyes, or on the muzzle. This condition was considered to be similar to a condition which was earlier described from the Wisconsin Station in Holstein-Friesians. The evidence indicated the

operation of a single recessive gene as the causative factor. Another type of semihairlessness was described in Jersey cattle by the Texas Station. The Idaho Station found that wry tail was inherited and was due to a single Mendelian recessive in a Jersey herd. Three generations of normal sires were evidently heterozygous carriers of the recessive factor.

Inbreeding swine.—Three lines of Poland-Chinas were inbred by brother-sister matings for five, six, and eight generations, respectively, at the Minnesota Station but three other lines were lost in the first generation and one in the third generation due to the reluctance of boars to mate with their litter-mate sisters. This difficulty was experienced in other lines but was no longer a problem after the fifth generation. The lines developed differed significantly in temperament and disposition. In one line, the sows were vicious at parturition, whereas the sows of another line were very docile. Although the inbreds were less vigorous than noninbreds, as indicated by litter size, mortality, and rate of growth, differences were small and crosses between inbred lines reached a weight of 200 pounds 4 weeks earlier than noninbreds and 7 weeks earlier than inbreds. Few color and physiological abnormalities appeared in the stocks.

Effect of inbreeding on poultry.—As a result of 10 years' experience in inbreeding poultry by different methods at the Iowa Station, it was found that little or no reduction in egg production, fertility, and other characteristics related to vigor occurred. The inbreeding in the six different lines ranged from 41 to 82 percent. Increasing the degree of inbreeding showed no general decrease in the percentage of fertile eggs produced, although a slow but gradual decline in the hatchability of fertile eggs was noted. The average hatchability for all birds, however, was in most cases well above 60 percent. The most intensely inbred fowls matured an average of 16 days earlier than birds in the noninbred foundation stocks. There was no marked decrease in the 200-day egg production in any one of the six lines as inbreeding increased and egg weight was well maintained. Although growth rate and adult body weight were not affected by the inbreeding, pullet mortality showed a marked rise in the intensely inbred lines with the exception of the family having an inbreeding coefficient of 70 percent. The results lend support to the hypothesis advanced that inbreeding concentrates the qualities present in the stock. If sufficient vigor, vitality, and desired characteristics are present in foundation animals, inbreeding can be practiced without deleterious effects.

Inheritance of rate of growth in fowls.—A study was made of the skeletal dimensions of Golden Seabright Bantams and Light Brahmas and the F_1 and F_2 crosses between them at the Wisconsin Station. The results showed that the F_1s and F_2s were slightly smaller than the average between the parents. The hybrid females sired by the Brahma male were significantly longer in the leg and wing bones than the females of the reciprocal cross, suggesting sex linkage of size genes. Correlation coefficients above 0.9 between different skeletal measurements of the F_2 progeny suggested the operation of general size factors. High correlations were also obtained between skeletal measurements and cranial measurements of the birds in this

generation. No association was apparent between the shank-color or comb-type genes and size.

An analysis of the results of a study made at the California Station of the rate of growth of White Leghorns and Barred Plymouth Rocks from hatching to 24 weeks of age suggested that the most suitable age for studying genetic differences in growth rate was between the second and eighth week of age on account of the clearness with which differences are demonstrated at this period.

Plumage characters.—In studies on the inheritance of plumage characters the sequence of appearance, molt, and replacement of the feathers is of considerable significance. The Kansas Station made such a study of fowls of several breeds, guineas, and turkeys and concluded that they all agreed closely in the irregular sequence of emergence and molt of the axial feather and secondary no. 1. The various flight feathers emerged at about the same time in the White Leghorn, turkey, and guinea but appeared somewhat later in the Rhode Island Red and Light Brahma. A complete molt of the flight feathers usually occurred during growth in the chicken, but the original outside primary feather occasionally was carried over into the adult period. Occasionally, a second molt was observed in chickens when sexual maturity was approached. In an investigation of the relation of juvenile plumage to growth and sexual maturity, the Pennsylvania Station through observations on 90 female and 73 male Single Comb White Leghorns from hatching to 20 weeks of age, showed that there were two peaks of body molt and one complete wing- and tail-feather molt following the original growth of the feathers, but significant changes in growth rate did not occur during these periods. There was some tendency for early-maturing pullets to carry over one or more chick feathers during the first laying year. Primary feather development at 8 or 10 weeks of age could not be used as an accurate indication of forecasting date of first egg.

Incomplete dominance of dominant white at least in crosses with wild color types was observed at the Iowa Station. The heterozygous chicks showed the appearance of spots on second chick feathers not shown by the homozygotes. It was further observed that homozygous crested, homozygous noncrested, and heterozygous crested birds could be distinguished at hatching by the presence of a cranial hernia in the homozygous crested birds. This condition was lacking in heterozygous and noncrested birds. The latter two types could be separated by the attachment of the comb which was shortened in heterozygous crested birds.

Frizzle fowls.—The Frizzle fowl has a defective type of plumage which results in excess loss of body heat. As a result there is interest in a determination of the comparative weights and histology of the different organs in these birds with similar organs and glands in normal fowls. The Connecticut (Storrs) Station found that Frizzle fowls showed definite increases in the relative weights of thyroids, heart, blood, spleen, kidneys, adrenals, pancreas, crop, and gizzard and in the capacity of the intestinal tract. Distinct differences in the fat deposits of Frizzles and normal chickens were also observed. Young Frizzles were almost without fat deposits while

older Frizzles tend to have excess fat accumulation. The high rate of metabolism was associated with the increased size of the thyroids and adrenals. Although it was concluded that the Frizzle gene was directly responsible for the plumage defect alone, it seems likely that residual heredity plays an important role in determining the degree of variation in organs and functions and their relation to survival.

Lethal genes in the fowl.—Increased importance is being attached to the operation of genetic factors causing high rates of mortality. It is well known that approximately 25 percent of the embryos produced by matings of Creepers die. This is due to the fact that the Creeper gene in the homozygous condition is lethal. The Connecticut (Storrs) Station found that the reduced hatchability in Creeper fowls was not only due to this genetic factor but to nongenetic agencies such as variability in shell weight and defective bone structure. In cooperation with the Strangeways Research Laboratory in England, it was suggested that the abnormalities of Creeper embryos are due to unspecific growth retardation. Matings of Dark Cornish fowls produced eggs of which 27 percent on incubation developed abnormal embryos. These abnormalities involving failure of the eggs to hatch caused shortened extremities and a short, broad head with bulging eyes. It is suggested that probably several dominant and recessive genetic factors are responsible for the shortness of the extremities frequently observed in Cornish fowls. The Iowa Station presented data on the sex ratio of the progeny of certain White Leghorn sires and their sons which suggested that several of them transmitted a sex-linked recessive lethal gene.

Action of hormones on reproductive cycle.—The work of the experiment stations primarily with rats and mice has supplemented the work of other institutions in determining the influence of hormones of the pituitary on the gonads and the subsequent effect of the hormones of the ovaries on the genital tract and mammary gland. Special attention was given by the California Station to the study of substances which stimulate the action of the gonadotropic hormones in bringing about ovulation in immature rats. Substances found effective in this respect were zinc sulphate, egg albumen, and casein. The effect was considered due to a delayed absorption of the active principle, thus stimulating ovarian growth over a longer interval. Other studies included determination of the content of the hormone stimulating ovarian growth in the anterior lobe of the pituitary of rats of different ages. In these studies glands were intramuscularly transplanted. The results showed that the male pituitary reaches its highest potency at from 28 to 31 days of age, and that glands from females of 18 to 28 days of age are equivalent to the highest potency reached by males.

It is the usual practice in testing substances for the content of the hormone which will produce oestrus to administer the extracts subcutaneously. However, the California Station showed that more positive results could be obtained in the production of cornified epithelium in the vaginal smear with smaller doses applied directly to the vaginal epithelium of rats. Further information was thrown on the influence of the hormones of the anterior pituitary gland in studies at the California Station by inducing maternal behavior in

adult male rats through the chronic administration of bovine anterior pituitary implants. Such males made nests for young rats and showed a general mothering tendency.

Oestrin, a hormone from the ovary, is found in the fluid of the Graafian follicle and another hormone is present in the corpus luteum. However, the Kansas Station found that extracts from sows' ovaries after removal of the follicular fluid and corpora lutea caused precocious sexual development in 21-day-old mice and rats. The vaginal smear from these animals was characteristic of oestrus. Pituitary transplants from these animals to other immature females produced similar results. In further studies along these lines, the Wisconsin Station found that the action of the follicle-stimulating and luteinizing hormones of the pituitary on the ovaries of immature rats was enhanced by administering these two substances in combination. In connection with studies at the same station of the normal reproductive cycle in the cat, experimental ovulation was induced in anoestrous, pregnant, and immature cats by injections of the follicular-stimulating fraction of the anterior pituitary followed by intravenous injection of the follicular-stimulating hormone or luteinizing extract, alone or in combination.

Physiology of mammary gland development.—Because of the relationship of the pituitary gland to the reproductive cycle, it is important to control the influence of this gland. Consequently, experimental animals frequently have the gland removed and definite amounts of extracts or transplants subsequently administered. Oestrin administration to normal and hypophysectomized male guinea pigs at the California Station caused about equal development in the nipples but lactation occurred only in the animals possessing normal pituitary glands. The Missouri Station found that a period of treatment with the follicular hormone in excess of 10 days was required before the mammary glands of rabbits not in oestrus or recently ovariectomized during oestrus would respond to the influence of galactin, a hormone of the pituitary gland which directly influences mammary-gland development and lactation. The New York (Cornell) Station showed that lactation in the rabbit seemed to depend for its complete expression upon a hormone of the corpus luteum.

Hypophysectomy in the goat.—Because of the close relationship of the pituitary gland to the hormones essential to reproduction and lactation, considerable interest has arisen as to methods for removing this gland from animals and for experiments dealing with these relationships. In connection with this work, the Missouri Station developed a method for locating the gland through the sphenoid bone and for its removal with an electrical high-frequency cautery. The operation on goats caused a decline of from 50 to 75 percent in the milk production from 1 to 2 days following, but milk flow soon recovered to the previous level. The same station further studied histological changes in the mammary gland following cessation of milking in the goat by the removal of small blocks of mammary gland tissue. The results showed that the suspension of milking 30 days after parturition resulted in a degeneration of the lobule-alveolar system and only the duct system remained after 75 days. Cessation of milking of the teats on one side of the udder had no

effect in retarding involution of the gland on the opposite side which was being milked.

Physiology of reproduction in cows.—Sterility in cattle may be due to many causes. In studies with cows proving sterile after several matings, at the New York (Cornell) Station, it was found that injections of Progynon B, a proprietary product of the pituitary gland, brought about marked improvement in the blood supply to the uterus. The increased blood supply permitted implantation of the embryo, and in several previously sterile cows normal pregnancy occurred after breeding. Although the number of animals so tested was not sufficient for final conclusions the results appeared favorable. Matings with conceptions were also reported from the Wisconsin Station in the treatment of a few shy breeding cattle with pituitary extracts.

Supplementing previous investigations in which the mammary glands of virgin female and male animals were brought into active stages of milk secretion by such treatment, the New York (Cornell) Station was able to increase the milk yield of goats by injections of galactin, a hormone of the pituitary gland specific for lactation. It appears that milk secretion is controlled by three factors—(1) ovarian hormones, (2) aging of the cells of the mammary gland, and (3) hormones of the pituitary gland.

Reproductive cycle in swine.—Intelligent practices in mating and breeding swine depend upon a knowledge of the physiological processes associated with reproduction. The Wisconsin Station investigated the development of the ovary of the immature sow giving special attention to the response of such ovaries to the administration of hormones which in the mature animal cause ovulation. The responses in the prepubertal sow were largely negative. In studies of the processes of reproduction in mature sows, the Missouri Station found that normally ovulation occurs 32 to 37 hours after the onset of the heat period. About 5 hours were required for spermatozoa to travel up to the midregion of the uterine tubes. As sows go out of heat shortly after ovulation, matings would be suggested at about 27 to 32 hours after the onset of heat in order that spermatozoa may be available for prompt fertilization of the ova after the follicles rupture.

Physiology of reproduction in sheep.—To determine the optimum time of breeding ewes to insure conception, the Minnesota Station made a study of the presence or absence of sperm in different portions of the reproductive tracts of 20 ewes killed at intervals following mating. These results indicated that ovulation occurs very late in the heat period, and that the life of the sperm and ova was less than 24 hours. Sperm travel rapidly through the reproductive tract, reaching the anterior end of the oviduct approximately 5 hours after copulation. It was therefore suggested that the optimum time for mating ewes was during the last 5 or 6 hours of the heat period. Similar results regarding the rate of travel of spermatozoa in the uteri of ewes were obtained in studies at the Massachusetts Station.

The Missouri Station attempted to modify the heat period of ewes so that the breeding season could be advanced. Moderate doses of extracts from human pregnancy urine and whole-blood serum

from pregnant mares were employed. About 70 percent of the ewes treated with these substances during June, July, and August came into heat, as contrasted with 35 percent of the controls. The use of these hormones seems to offer a possibility for altering the breeding season and thus gaining greater control of flock fertility. The California Station found that heat periods and ovulation could be induced by the administration of gonadotropic hormones from the pituitary given at 17-day intervals during the anoestrum period. Ovulation was induced by the gonadotropic hormones without the phenomena associated with the heat period when administered with oestrin.

Physiology of reproduction in the fowl.—To investigate egg formation in the fowl, various sections of the oviduct were removed at the California Station. Taking a section from the wall of the uterus modified the shell and shell membrane, whereas the shape of the egg was not changed except after resectioning a part of the isthmus. Removal of a part of the albumen tube of the oviduct reduced the amount of thick albumen in the egg laid.

Blood serum from pregnant mares has been found to stimulate precocious sexual development in rats, and the California Station showed that immature male and female White Leghorn chickens treated with serum from pregnant mares showed an increase in the size of the testes and ovaries, and spermatogenesis and ovulation were probably induced.

Chemical substances affecting growth.—Because of the relationship between the concentration of a chemical substance known as glutathione in animal tissues to rate of growth and body size, the California Station determined the influence of fasting and nursing on the glutathione concentration in the whole carcasses of newborn rabbits. The results of this study showed that the glutathione concentration was nearly doubled in a group of rabbits that gained 15.9 grams during a 50-hour period as contrasted with the fasted group which lost an average of 7.5 grams during the same period. The glutathione concentration was related to the growth and development of the animal. However, the glutathione content of the livers of rats given single injections of the growth hormone of the pituitary decreased 30 percent in 8 hours and 55 percent in 12 hours as compared with controls. Administration of the growth hormone had no significant influence on the moisture content of the muscles, although significant decreases in the moisture content of the livers followed administration of the growth hormone.

Embryo development of laying hens.—Investigations at the Kentucky Station showed that the calcium and phosphorus content of the embryos in the eggs from hens receiving no sunshine nor vitamin D supplement was much less than that of embryos in eggs laid by hens receiving direct sunlight or cod-liver oil. The greatest difference occurred at the eighteenth and nineteenth day of incubation, indicating a direct relationship to the high period of embryo mortality. Adding cod-liver oil to a ration fed to pullets confined to a house without direct sunshine, to housed pullets with a wire-screened porch, or to pullets allowed bluegrass range, decreased embryo mortality during the third week of incubation. The decrease was most marked in the confined lot with only a slight decrease in the bluegrass lot.

The temperature requirements for the first part of the incubation period are rather rigid. The New York (Cornell) Station found that temperatures during the first part of the incubation period above 38° or below 37° C. lowered hatchability, but that after the sixteenth day incubation temperatures could be lowered as much as 3° without producing ill effects. The high and low extremes markedly increased the number of crippled chicks.

Interesting observations were reported by the Iowa Station regarding the normal position of live embryos in more than a thousand eggs. All of the embryos examined on the eighteenth day were in the normal hatching position, but on the nineteenth day of incubation only 7.8 percent were in the normal hatching position and on the twentieth day 50.1 percent. It is evident that following the eighteenth day changes in position normally take place within the egg, and as a result many of the embryos dying between the eighteenth and twentieth days of incubation would be considered in abnormal position. The position has no doubt been erroneously designated as the cause of death of many embryos dying at this period.

NUTRITION

Nutrition studies have been developed to determine the values of feeds and their various components for different kinds of animals. On the other hand, it is equally necessary to know what elements the animal organism needs for its maintenance and the performance of work. These requirements have been found to vary with different animals, and under different environmental conditions. Among the outstanding contributions of such studies are the role of vitamins in the diet and the effect of natural mineral deficiencies. While many problems have been solved, there still remains a vast background of unexplained problems facing the animal producer. Some samples of recent contributions to existing knowledge are presented.

Vitamins in animal nutrition.—In determining the nutritive properties of pasture plants, it is desirable to know something of their vitamin A content. At the Idaho Station, first-year sweetclover was found to contain 500±30 rat units of vitamin A per gram; smooth bromegrass, 396±27; redtop, 308±10; orchard grass, 275±13; alfalfa, 269±19; meadow fescue, 250±13; second-year sweetclover and white clover, 242±19; timothy, 220±13; and Kentucky bluegrass, 175±11. These values justified the conclusion that pasture is an important source of this vitamin. Considering the large quantity of pasture consumed daily by the dairy cow, it would seem that livestock men might use mixtures of any of the pasture plants adapted to their particular climatic and soil conditions without the vitamin A activity of the pasture being a limiting factor in production. The California Station suggests that feed dealers and cooperatives who are buying large quantities of alfalfa meals primarily as a source of vitamin A in rations should consider purchasing on the basis of carotene content. A simple method of making such a test has been developed, making possible a reasonable degree of standardization of products prepared especially for their vitamin A value. It is pointed out that not only in curing but in storage is carotene lost from alfalfa and its products.

The Wisconsin Station found that the antirachitic activity of certain fish oils, such as cod-liver, halibut-liver, tuna-liver, turbot, and sardine oils, was not increased by irradiation. The comparative antirachitic effectiveness of the fish oils, as determined with chicks and rats, was approximately the same. Irradiated plant oils, coconut, wheat-germ, and peanut oil, were less effective antirachitically for chicks than such irradiated animal fats as lard and chicken fat, on an equivalent unit basis. The use of solvents for vitamin D did not increase its effectiveness.

Nutritive value of proteins.—The New York (Cornell) Station conducted a series of metabolism studies with growing wether lambs to determine the digestibility, storage, and biological value of the proteins of soybean-oil, corn-gluten, and linseed meals. The average coefficients of apparent digestibility of the above meals were 67.0, 66.3, and 63.3 percent, respectively. The average percentage of protein intake stored for the respective feeds was 33.8, 26.5, and 26.7. The average biological values were 72.8, 65.7, and 67.7 for the respective proteins. The results showed the superiority of the proteins of soybean-oil meal over those of corn-gluten and linseed meals.

Protein requirements after middle life.—In experiments with rats at the New York (Cornell) Station it was shown that the protein level of the diet had considerable effect on health after middle life. Rats averaging approximately 440 days of age at the start were fed rations containing protein levels of 8, 14, and 20 percent. The animals receiving the highest level showed significantly higher values for nonprotein nitrogen in the blood and for albumin in the urine than did those on the lower intakes. It appeared that a diet containing 20 percent of protein was less favorable to health after middle life than one containing a lower level.

Zinc in nutrition.—While zinc has been recognized as a necessary factor in plant nutrition, its role in animal nutrition has not been clearly understood. When rations extremely low in zinc were fed to rats at the Wisconsin Station, the animals did not grow, the hair failed to develop, and where the coat was spotted black it became dull gray in color. When zinc salts was added to the rations of such animals, growth proceeded normally, the poor color of the hair disappeared, and the harshness of the coat gave way to a soft, silky texture. These results made it evident that zinc was an essential element for rat nutrition, and probably for mammalian nutrition in general. (See also p. 138.)

Effect of selenium on reproduction.—Wheat containing 24.6 parts per million of selenium, when fed to rats 42 days of age at the South Dakota Station, reduced the food intake and brought about a loss of weight. Older animals gained in weight on the toxic feed. In no case was a litter produced when both the male and female had been on the toxic diet. Males that were placed on the toxic diet at 63 or more days of age were able to fertilize normal females but were unsuccessful with females on the toxic diet. There appeared to be little development of the female reproductive organs after the animals were placed on toxic diets. In mature animals the toxic diet caused a marked atrophy of the reproductive organs.

Correcting toxicity of gossypol.—The toxicity of gossypol in rat diets containing cottonseed meal was reduced at the Oklahoma Sta-

tion by adding 2 percent each of calcium carbonate and sodium bicarbonate. The value of sodium bicarbonate combined with calcium carbonate or in the presence of normal amounts of dietary calcium was attributed to its solubility with the production of an alkaline medium in which gossypol was unstable and susceptible of precipitation. The action of the salts in gossypol diets was one of detoxication, involving a reaction between gossypol and calcium in an alkaline medium.

Vitamin A requirements of cattle.—The California Station found that of the total storage of vitamin A in the liver and body fat of cows, 76 to 93 percent was in the liver, while the amount in other organs was negligible. In the liver, storage was largely in the form of vitamin A, while in the fat carotene predominated. The concentration of reserves in young animals as compared with that of aged adults suggested that reserves above a certain level accumulate slowly. Using night blindness as a basis on which to determine the minimum requirement, it was found that the daily minimum of the bovine was 26 to 33 micrograms per kilogram of live weight. The hypothesis was advanced that vitamin A requirements were related to body weight rather than to energy requirements, and that the minimum requirement of mammals was approximately 20 to 30 micrograms of vitamin A (or carotene) daily per kilogram of body weight. This implies that large animals require a higher percentage of vitamin A in the diet than do small animals in order to compensate for the lower feed consumption per unit of weight.

Mineral requirements of dairy cattle.—Many roughages grown on sandy soils were deficient in calcium in tests at the Florida Station. A 45-percent greater milk yield was obtained on rations adequate in calcium as compared with rations deficient in this element. Adding ferric ammonium citrate, copper sulphate, and bonemeal to the ration during the period of gestation produced calves that were more vigorous and more resistant to common calf ailments.

Development of tetany has been observed in calves fed a whole-milk ration. The Michigan Station has obtained evidence that this may be the result of magnesium deficiency and has shown that rations from natural foods must contain from 8 to 10 milligrams of magnesium per pound of body weight to meet this requirement. Both summer and winter milk appeared to meet the vitamin D requirements of growing calves if the ration contained adequate amounts of assimilable magnesium. The fact that calves receiving summer milk required more vitamin D than those receiving winter milk was tentatively attributed to a deficiency of magnesium in the summer ration. The addition of magnesium carbonate to a rachitogenic ration failed to prevent the manifestation of clinical rickets in calves. There was, however, better calcium and phosphorus utilization as a result of adding the magnesium, indicating that the magnesium content of feeds for dairy cattle may contribute to their antirachitic effect.

A ricketslike disease in young cattle.—A ricketslike disease occurring in calves during the fall, winter, and spring months was found by the Minnesota Station to be caused by failure to provide sufficient vitamin D and calcium. Various clinical forms of the syndrome occurred, depending on the relative degree of deficiency

of the two factors. The condition seriously interfered with a normal growth and development. Enlargement of the joints with considerable erosion of the articulating surfaces and the production of thin, fragile walls on the shafts of the long bone were apparent. The onset of the disease was invariably followed by varying degrees of anorexia, a downward trend of the blood calcium, and a similar but less marked trend in inorganic blood phosphorus. Prevention or correction of the disease was effected by the use of sunshine, viosterol, sun-cured hay, and cod-liver oil as sources of vitamin D and a good quality of legume hay or some supplement rich in calcium.

Minerals for swine.—A low-phosphorus diet at the Kansas Station caused a loss of appetite, poor utilization of feed and storage of energy, a failure to make normal growth and to develop bone and muscle normally, a lowering of inorganic phosphorus in the blood, and a marked increase in thirst with a corresponding excretion of urine. Differences in the averages of hemoglobin levels at birth between groups of pigs at the Oklahoma Station were insignificant, but in all cases the levels declined between birth and 1 week of age. However, when pigs had access to soil containing approximately 250 pounds of easily soluble iron sulphate per acre or soil supplemented with ferrous sulphate and copper sulphate, the decline was not as great as in the control lot. The hemoglobin level increased for all groups between the first and second week and again the treated groups were favored. An average of one pig per litter was lost due to anemia between the third and fourth week of age in the control group, but no losses that could be attributed to anemia occurred in the treated groups. Excessive amounts of available fluorine in the ration at the Ohio Station reduced the growth and feed consumption and increased the feed required per unit of gain for pigs. When rations contained more than 0.029 percent of fluorine, as sodium fluoride, or more than 0.033 percent, as rock phosphate, the bones of pigs were characterized by increased thickness, loss of normal color and luster, presence of exostosis, and a decreased breaking strength. The bones contained normal amounts of ash, calcium, and phosphorus, increased amounts of magnesium and fluorine, and decreased amounts of carbonates. The increase in the thickness of the jaws of pigs on fluorine diets was due to an increase in the size of the medullary spaces. Changes also occurred in the bone marrow and teeth. High levels of fluorine had no direct effect on reproduction but adversely affected lactation through decreased feed consumption. Rock phosphate could be fed to pigs at 0.5-percent levels for short periods without danger of toxicity.

Soybean-oil meal.—The nutritive value of the protein of soybean-oil meal was affected, according to the Wisconsin Station, to a considerable extent by the process of manufacture. Commercial soybean-oil meals prepared at medium and high temperatures, as, for example, in the expeller process at 112° to 130° C. and 140° to 150° for 2.5 minutes, or hydraulic meals cooked at 105° and 121° for 90 minutes, contained proteins which had about twice the nutritive value of the raw soybeans or those prepared at low temperatures. Heating the extracted soybeans at 98° for 15 minutes, as in the commercial solvent method of oil extraction, was also an effective

method of heat treatment. It appeared that some essential fraction, which was unavailable in the raw soybean, became available for absorption and assimilation due to heating. (See also pp. 102, 105, 108.)

Vitamin requirements and sources for poultry.—Investigations by the Idaho Station showed the importance of vitamin A for maintaining normal health and resistance to colds and specific infections in laying hens. The vitamin A requirements of the laying hen were greater than those of growing chicks. A mash containing a variety of feeds furnishing a combined source of vitamin A afforded complete protection to birds even though the scratch mixture consisted entirely of white grains. Results at the New Jersey Station indicated that the present intake of vitamin A by poultry flocks was adequate and it was not necessary to use additional supplies of the vitamin in the poultry ration. In studies at the Texas Station there appeared to be little gain or loss of vitamin A by laying hens, and it was not possible to separate the requirements for maintenance from those for eggs. On the average, four units of vitamin A in the feed were required for one unit of vitamin A potency in the egg. It was estimated that hens producing 150 eggs high in vitamin A per year would require approximately 600 Sherman-Munsell units per day or 25 units per gram of feed. When the vitamin A content of the eggs was disregarded, hens could be kept in good health and production on approximately 240 units of vitamin A per day or 3 units per gram of feed.

The Iowa Station observed that the vitamin D content of hens' eggs was markedly increased by fortifying the ration with vitamin D supplements or by exposing the hens to sunshine. There was a noticeable difference in the efficiency with which vitamin D from different sources was transferred to the egg. The vitamin D activity of eggs laid by the same hen or by different hens receiving the same fortified ration was remarkably uniform. Ten percent of the vitamin D factor consumed appeared in eggs at the New Jersey Station. Sunlight appeared to be more effective in increasing the antirachitic potency of egg yolk than the amount of cod-liver oil ordinarily fed. At the Missouri Station sardine oil proved to be a very satisfactory source of vitamin D for chicks, and normal growth was obtained with rations containing 0.5 percent. Concentrated cod-liver oils promoted satisfactory growth when fed as one-eighth and one-sixteenth of 1 percent of the ration. Highly concentrated oils were not recommended for home-mixed rations because of the difficulty in getting an even distribution of the oil in the mash. In experiments reported by the Ohio Station, egg production, eggshell quality, and hatchability of the eggs were greatly influenced by the supply of vitamin D even when other conditions were favorable. Feeding adequate amounts of vitamin D or giving hens access to direct sunlight after 6½ months on a ration low in or devoid of the antirachitic factor again stimulated and increased egg production, eggshell quality, and hatchability. Irradiated ergosterol was not so efficient a source of vitamin D for laying hens as cod-liver oil and in excessive doses was toxic to the birds. The antirachitic potency of egg yolk depended on the vitamin D intake of the birds producing it.

The antirachitic potency of egg yolk, the Pennsylvania Station found, depends on the antirachitic potency of the ration fed. The

ability of the hen, however, to transfer the antirachitic factor or factors from her diet to the egg appears to be limited. "The antirachitic potency of cod-liver oil appeared to be more efficiently transferred from the diet to the egg yolk than was an equal unitage of viosterol."

Yearling hens, nearing the end of a period of egg production, produced egg yolks that were more potent (antirachitically) than did pullets at the beginning of their initial period of egg production. It is suggested that this difference in potency might be due to the rate of egg production and not to the period of production.

The Wisconsin Station reports the results of experiments which show—

that for the chick and per unit of vitamin D, irradiated milk, cod-liver oil, and irradiated cholesterol are of approximately the same order of effectiveness; yeast milk is approximately one-tenth as effective as irradiated milk. This difference was confined to the respective butterfat fractions and was not influenced by the skimmed milk fraction; the constituents of milk as a vehicle for vitamin D do not influence its effectiveness.

The experiments gave no support to the possibility that the baby chick could be used to greater effectiveness than the rat for ascertaining the degree of antirachitic effectiveness of vitamin D for the human.

Mineral requirements of poultry.—When chicks at the South Dakota Station were fed a ration containing 65 percent of grain grown in selenium-bearing soils, distinctly inhibited growth resulted. When about 4 weeks old, the chicks had ruffled feathers and showed noticeable nervousness. Egg production was both delayed and reduced by the ration, but no distinct lesions of the internal organs were found.

The Alabama Station has shown that chicks can live only a few days on diets free from potassium and magnesium. Lack of magnesium produced tetanic convulsions and skin disorders, while lack of potassium produced marked edema of the intestinal tract. Hens were supplied with iodine from various sources at the California Station. Such sources as oystershell, potassium iodide, iodosalicylic acid, di-iodotyrosine, and iodized olive oil had no adverse effect on body weight, egg production, or feed consumption. Desiccated thyroid and heavy doses of sodium iodide did affect the birds adversely. It was apparent that iodine utilization by the laying hen, insofar as it could be measured by the iodine content of the eggs and the excreta, depended upon the source as well as the amount of iodine given.

There is a well-established belief, according to the Wisconsin Station, among many practical poultry breeders that salt is poisonous to chickens. Many instances have been reported of chickens having been killed by eating salty meat, salty kitchen wastes, and salty bakery wastes. Results of experiments by the station indicated that 5 percent of salt in the ration was more than was desirable, that 2 percent of salt was not injurious but did not seem to be advantageous, and that groups getting more than 1 percent of salt consumed more than a normal amount of water, with the result that the litter had to be changed frequently. There appeared to be an advantage in having some salt in the ration, but when such feeds as

meat scraps and dried milk were used it was not necessary to add more than one-half pound of salt to 100 pounds of feed.

Nutritive value of packing-house byproducts.—Atmospheric and pressure-vacuum dry-rendered meat scraps were superior to wet-rendered tankage when fed to rats as a supplement to corn in mixed rations containing approximately 15.5 percent of protein of which 7.5 percent was derived from the animal byproducts, in experiments at the Indiana Station. There was no significant difference in nutritive properties of the atmospheric dry-rendered and pressure-vacuum dry-rendered meat scraps as supplements to corn for rats. There was practically no difference in the feeding value of digester tankage, atmospheric meat scraps, and pressure-vacuum meat scraps when fed free-choice with corn.

Haddock meal.—The New York (Cornell) Station found that dry-rendered haddock meal had a greater protein value and 50 percent more vitamin G than meals wet-rendered by a similar process of drying. A flame-dried meal was of inferior quality. The use of a vacuum with steam drying aided in the preservation of the vitamin G content, but did not improve the relative protein efficiency over that obtained without the use of the vacuum. Doubling the size of the charge in the dryer had a slightly beneficial effect. The vitamin G content was best preserved by not pregrinding the raw scrap.

Nutritive value of skim-milk powders.—The proteins of milk were shown by the Illinois Station to be very sensitive to the intensities and durations of heat treatment employed in commercial drying. In the preparation of choice commercial roller-process powders or of preheated spray-process powders, the preheating process lowered the biological value of the protein, although its digestibility was not appreciably affected. This initial decline was due to a partial destruction of cystine. As the temperature of drying in the roller process increased until perceptible scorching occurred, the biological value of the milk protein was rapidly lowered due to the destruction of lysine. The digestibility of milk protein was also lowered at the scorching point in the roller-drying process. Even with extreme scorching, the energy value appeared to be slightly, if at all, affected. The total solids and nitrogen of dry skim-milk powders were more soluble in spray-process powders than in roller-process powders.

Digestion trials with molasses.—Trials were conducted with steers at the Louisiana Station to determine the effect of molasses upon the digestibility of rations. Adding molasses to a ration containing no silage had no significant effect on the digestibility of the crude protein, ether extract, or crude fiber. The nitrogen-free extract and the ash digestibility were significantly increased, probably due to the fact that the molasses added these nutrients in a highly digestible form. Molasses added to a dry ration had no significant effect on the nitrogen balance. When added to a dry ration, molasses increased the ash, calcium, and magnesium balances, but did not affect the phosphorus balance. Adding silage to the dry ration had no significant effect on the digestibility of the crude protein and the nitrogen balance and increased the digestibility of the ether extract and ash.

Vitamin A potency of butterfat.—The Texas Station found that the natural yellow color of butterfat was directly proportional to

the carotene content of the ration, but the carotene content of the fat was not an accurate measure of the vitamin A potency. The relation between the carotene content and the vitamin A potency depended on the ration of the cow, the quantities of vitamin A and carotene stored at the beginning of the lactation period, the length of time during which a ration deficient in vitamin A or carotene was fed, the extent of such deficiency, and upon the individual animal. The butterfat from cows fed cottonseed meal and hulls averaged 2.5 units of vitamin A per gram. The butterfat from cows fed sorghum silage in addition to the above ration averaged 7.1 units of vitamin A, while that from a cow on pasture contained as much as 33 units. These tests indicated that the dairy cow has a high daily requirement for vitamin A. Cows receiving sorghum silage in addition to cottonseed meal and hulls developed symptoms of night blindness and other disorders, showing that the ration did not supply sufficient vitamin A for good health. The vitamin A content of milk produced at the New Jersey Station on rations consisting of various combinations of field-cured and machine-dried alfalfa hay, corn silage, beet pulp, yellow corn, and corn-gluten meal, decreased as the proportion in the feed increased. In no instance did the output of vitamin A in the milk exceed 3.5 percent of the intake in the ration. It was apparent that the increase in vitamin A content of the milk was not proportional to the increased consumption of this factor.

Feeding vitamin A into butter.—The effect of alfalfa and soybean hay cut at different stages of maturity and cured in different ways on the vitamin A activity of butter produced was studied by the Indiana Station. The results showed that artificially dried hays were superior in vitamin A value to the corresponding field-cured hays. Hays made from younger plants possessed a higher vitamin A value than did hays made from older plants. Alfalfa plants contained greater vitamin A potency than did soybean plants. Dairy cows when fed artificially dried hays produced butter of higher vitamin A value than when fed field-cured hays. When fed artificially dried young alfalfa hay, cows produced butter containing 45 units of vitamin A per gram. Soybean hay made from plants after the beans were well formed in the pods suppressed the formation of vitamin A in butter. Soybean hay made from young plants had no such suppressing effect on the vitamin A activity of butter.

BEEF CATTLE

Management studies.—"Handy weight" fat beef carcasses of Good to Choice quality were produced at the Missouri Station by "creep-feeding" well-bred winter and early-spring calves while they were nursing their mothers. Sixteen and a half bushels of corn, 116 pounds of cottonseed meal, plus good pastures and mother's milk, were required to produce 677 pounds of fat calves in 10 months. At the same station, cattle finished in dry lot after feeding on bluegrass pasture until about the middle of July gained more rapidly and produced somewhat better carcasses than those fattened entirely either in dry lot or on pasture. A method of feeding beef calves that has given good results has been developed by the Illinois Station and is attracting much attention among feeders. The calves are fed on

grass during the winter instead of being fed on green grass during the summer. The grass is permitted to grow unused during the growing season, and the calves are placed on the dry grass early in the winter.

Breeding studies.—Livestock breeders are interested in the introduction of a minimum of outside blood which will enable them to concentrate on the production of animals showing superior characteristics and yet prevent the lowering of vigor ordinarily associated with inbreeding. The Iowa Station described a purebred Shorthorn herd in which no outside blood was introduced in over 20 years, the attempt being to conserve the good qualities of an outstanding sire. The study of this herd furnished a demonstration that a moderate-sized herd may follow a close breeding practice with one, later two, and finally one sire with an increase in the uniformity and merit of the resulting herd.

Pastures for beef cattle.—Kudzu is being used extensively throughout the South as a soil-conserving and soil-building crop. In addition to being useful for conserving and improving land, kudzu is apparently a useful forage crop. In a determination of the carrying capacity of kudzu when grazed with beef cattle, the Alabama Station showed that 1 acre of kudzu furnished grazing for an animal unit for a period of 65 days. The average amount of beef produced per acre was 95 pounds each summer. This crop was most valuable when used as a temporary grazing crop to supplement a permanent pasture. It furnished excellent grazing during midsummer, a period when permanent pastures were poor. At the Missouri Station it was possible to retain the relatively large gains made by cattle on bluegrass pasture during the spring and to continue the gains through July and August by using good Korean lespedeza pasture during these months. Continuous utilization of the same pasture often resulted in complete loss of spring gains during a hot, dry summer. Systematic rotation from one bluegrass pasture to another tended to improve the stand of bluegrass.

In cooperation with the Department (B. P. I.) the Florida Station determined the relative grazing value of Bahia, Bermuda, carpet, and centipede grasses, in pure stands and in a mixture of all. Yields as measured by lawn-mower clippings were highest in the Bahia and mixed-grass pastures and lowest in the centipede grass pasture. The crude-protein content was highest in the carpet grass and lowest in the centipede grass pastures. Cattle made the largest gains on the centipede grass. With the exception of the latter grass, there was a close relationship between grass yields and cattle gains. The growing habits of the centipede grass, which made it difficult to clip a large portion of the plant, was at least partially responsible for its poor yield record.

Hardness of cottonseed cake.—The Texas Station found that the average crushing strength of cracked cottonseed cake varied from 127 to 3,698 pounds and of slab cake from 710 to 3,427 pounds. Crushing tests on the molar teeth of cows ranged from 1,080 to 4,550 pounds, with an average of 2,165 pounds, while for sheep the range was from 420 to 1,430 pounds, with an average of 1,108 pounds. The size and shape of the cake markedly affected the crushing strength with the smaller pieces being lower in this respect. The "boot heel test",

used by stockmen to determine the hardness of cake, crushed samples with a crushing strength of less than 450 pounds. Soaking in water decreased the crushing strength of a sample about one-third for the first 5 minutes of soaking. Tests with cattle and sheep showed that while size, shape, and hardness of cake had some effect on consumption, the individuality of the animal appeared to be a controlling factor. On the basis of the results obtained, cake with a crushing strength of less than 400 pounds was tentatively classified as soft, that with a crushing strength of 401 to 1,500 pounds as medium hard, that with a crushing strength of 1,501 to 2,500 pounds as hard, and that with a crushing strength of over 2,500 pounds as very hard for cows.

DAIRY CATTLE AND DAIRYING

Pasture for dairy cows.—Cultivated pastures have been found by the South Dakota Station to be highly profitable. In eight pasture seasons, cultivated pastures have returned from $28 to $32 per acre in butterfat at a price of 30 cents per pound for butter. In none of these years has rainfall been normal during the pasture season. Sweetclover and alfalfa have been more profitable than Sudan grass, mainly because they come earlier in the spring when the rainfall has been more abundant. At the Illinois Station greater yields of pasture crops for dairy cattle were obtained by sowing a combination of legume and grass crops, including winter rye, bluegrass, lespedeza, sweetclover, alfalfa, soybeans, and Sudan grass. Green grass seemed to be superior to other roughages in enabling the dairy cow to use and store the calcium and phosphorus in the grain ration. Adding a simple mineral mixture of equal parts of finely ground limestone, steamed bonemeal, and common salt to the grain ration while the cows were on pasture aided in building up the mineral reserve.

Roughage for dairy cattle.—Both the Arkansas and Illinois Stations found that lespedeza hay was a very satisfactory roughage for dairy cows. At the first of these stations, Korean lespedeza hay produced 2.5 percent more milk and 16 percent more butterfat than alfalfa hay. The latter station found that, as judged by milk yields, gains in weight, and health of dairy cows and heifers, lespedeza hay was equal to alfalfa hay. Lespedeza hay was somewhat less palatable and was lower in protein, fiber, total ash, and lime content than alfalfa hay. Ground Russian-thistle hay was used with fairly satisfactory results to furnish 40 to 45 percent of the protein and total digestible nutrients of a dairy cow's ration in experiments at the Kansas Station. This hay contained 62.1 percent as much total protein, 55.2 percent as much digestible protein, and 80.5 percent as much total digestible nutrients as did alfalfa hay.

Succulent feeds.—A large percentage of the carotene in an alfalfa-clover crop was preserved at the Ohio Station by treating it with sufficient mineral acids to produce a pH of 3.6 as it was placed in the silo. The yellow color of milk produced by cows fed this silage was increased over that of cows fed liberal amounts of hay. The carotene value of the milk approached that from cows on pasture. The Washington Station determined that pea-vine silage contained 5.2 percent of digestible crude protein and 59.3 percent of total digestible nutrients. Experiments indicated a very high vitamin A

activity for pea-vine silage, which was likely to be reflected in the nutritive value of the milk. Silage made from 80 percent of apples and 20 percent of dry alfalfa hay was very palatable to dairy cattle. The dry matter of this silage contained 4.2 percent of digestible crude protein and 56.3 percent of total digestible nutrients. By using blackstrap molasses in making soybean silage, the South Carolina Station secured a silage which was palatable and readily eaten by dairy cows. The Illinois Station made good-quality alfalfa silage in metal and wooden tanks. The acid content of the silage was increased by adding whey powder, blackstrap molasses, and lactic acid starter. By mixing chopped green corn harvested at an early silage stage with chopped alfalfa, a good quality of silage was obtained. Alfalfa ensiled whole did not keep as well as chopped alfalfa. This silage was very palatable and when fed in limited amounts had a feeding value comparable to that of corn silage, but was more laxative.

Sweetpotatoes versus silage.—Chopped sweetpotatoes fed at the rate of 2 pounds per 100 pounds of live weight proved more effective than corn and soybean silage for milk production in experiments at the Louisiana Station. Butter produced on a sweetpotato ration had a higher color than that produced on silage. There were no noticeable ill effects on flavor of milk or butter or health of cows from feeding sweetpotatoes. When the grazing value of the vines is included, sweetpotatoes are not only a satisfactory but an economical dairy feed on many small farms.

Rye as a grain feed.—A good grade of either winter or spring rye used to the extent of 40 to 45 percent of the grain ration had approximately the same feeding value for milk production as a good grade of hull barley in studies at the Montana Station. No detrimental effects on the health or condition of the cows were observed when rye was fed. The quality of the milk and butter produced was excellent and fully equal to that obtained with barley. Since rye is a hardy, drought-resistant crop that can be grown where other grain crops are not dependable, the station suggests that farmers would profit by growing more rye for feeding purposes.

Soybean feeds for dairy cows.—Feeding trials at several of the experiment stations showed that soybean-oil meal was a good feed for dairy cows. At the Iowa Station it equaled and sometimes excelled linseed, cottonseed, and corn-gluten meals for milking cows. At the Ohio Station it produced results equal to those obtained with linseed meal, while the Virginia Station reported that it had about the same feeding value as cottonseed meal and peanut-oil meal. In tests at the Indiana Station, the average fat content of milk from cows fed expeller soybean-oil meal was slightly higher than that of cows receiving linseed meal.

Factors affecting lactation.—In investigations reported by the Florida Station it was found that a dry period of from 31 to 60 days permitted maximum milk yields of Jersey cows. A dry period of longer than 91 days appeared to result in lower milk production than did shorter dry periods. Dry periods of less than 30 days appeared to cause an early decline in milk yield. Under the relatively uniform seasonal environment of Florida, there was very little decline in milk yield aside from that due to advancing stage

of lactation. The maximum rate of production occurred during June and the minimum during November and December. There was a progressively greater rate of decline after the seventh month due to the inhibiting effect of advancing gestation.

Milk-goat breeding.—Successive generations of mating native does to purebred Toggenburg bucks at the New Mexico Station increased production in successive generations to an average of 1,505.2 pounds of milk and 56.16 pounds of fat per year for the does that were fifteen-sixteenths Toggenburg. The inbreeding of bucks to their daughters lowered production.

Vitamin C content of milk.—The Pennsylvania Station found wide variation in the antiscorbutic vitamin C content of the milk of individual cows of the same breed under like conditions of feed and management. Of five breeds studied, Brown Swiss produced milks of the highest ascorbic acid content, while Holstein-Friesian cows produced milk with the lowest value. Stage of lactation appeared to have a more definite effect on the ascorbic acid content of milk than did breed differences. The ascorbic acid content of milk was relatively high during the early stages of lactation but decreased to a minimum after about 2 months. The Kansas Station reported an average increase of 10 percent in the vitamin C concentration of milk from the first to the second month of lactation, but minor changes thereafter. The vitamin C content of milk was not changed appreciably within 60 hours after grass was first fed. Milk, either raw or pasteurized by the short-time, high-temperature process but uncontaminated with copper, could be held 35 hours without serious loss of vitamin C. The 30-minute pasteurizing process was not well adapted to the preservation of vitamin C.

Milk flavors.—Since an increasingly large proportion of commercial milk is being irradiated to increase its vitamin D content, the Wisconsin Station undertook to determine what effect the process has on the milk. Irradiation did not destroy vitamin B, the factor preventing polyneuritis, but vitamin C, the antiscorbutic factor, appeared to be destroyed by the process as now carried out. The first detrimental change was evidenced in off flavor and odors. If irradiation was stopped at this point, it apparently caused little or no practical injury.

Experiments at the West Virginia Station showed that milk pasteurized and cooled without contact with copper and handled thereafter without such metallic contact may be expected not to develop oxidized flavor. The contamination of milk with copper before pasteurization resulted in little, if any, developed flavor if no further contamination occurred. On the other hand, contamination with the same amount of copper after pasteurization resulted in a pronounced oxidized flavor. Surface cooling did not tend to increase the intensity of the oxidized flavor that may develop later. Homogenization, agitation at low temperatures, or freezing, followed by thawing, reduced or eliminated the susceptibility of milk to development of oxidized flavor. At the New York State Station it was found that the first milk passing through metal pasteurizers that had been sterilized with heat and chlorine solutions developed the oxidized flavor. On this basis it was recommended that the first milk through the plant equipment should be discarded.

Whipping cream.—The Maryland Station found that it required nearly 30 percent more time to whip Ayrshire than to whip Guernsey cream. The drainage from Ayrshire whipped cream contained 1.8 times as much fat as from Guernsey. The stability of whipped cream was not decreased by storing at 52° F., as compared with storing at 40°. Gelatin proved more effective in increasing the stability of whipped cream than did sodium alginate. However, the body of whipped cream to which gelatin had been added had a high gloss and was somewhat soggy, whereas the body of whipped cream containing sodium alginate was scarcely discernible from whipped cream containing no stabilizer. As little as 0.35 percent of gelatin was satisfactory for increasing the stability of whipped cream.

Storage of packaged ice cream.—The weight, volume, body, and texture of vanilla, strawberry, chocolate, and maple-walnut ice cream in quart and pint packages was not altered by storage at from −6° to −20° F. for from 16 to 24 weeks at the Vermont Station. Surface film developed in unlined but not in lined packages in from 3 to 4 months' time. Flavor began to deteriorate in strawberry in from 1 to 2 months and in vanilla in about 3 months; whereas the flavor of chocolate and maple-walnut remained unimpaired at the end of 4 months. It was concluded that the true age of an ice cream was measured by the age or condition of the ingredients of which it is made rather than by the length of time since it was last frozen. Ice cream had to be good to begin with or successful storage was impossible.

Age thickening of sweetened condensed milk.—The Wisconsin Station found that the unstable period for sweetened condensed milk began very abruptly and could occur any time from the middle of April to the middle of May in that State. There was no correlation between the freshening of cows or the time at which they were turned out on grass and the period during which the condensed product was unstable toward age thickening. Forewarming temperatures of 150° to 165° F. made a product which thickened less rapidly than heating the milk to only 135°. Temperatures from 189° up to boiling made the milk very unstable, while temperatures above boiling again made the milk less susceptible to age thickening. Increasing the acidity of raw milk caused the condensed product to thicken more rapidly during storage. Adding very small amounts of sodium bicarbonate to the raw milk during the spring of the year tended to stabilize the milk. The addition of sodium citrate either before forewarming or to the finished product stabilized unstable milk.

SWINE

Grinding feed.—Sustained interest in feed grinding has made it expedient for the experiment stations to investigate the desirability of processing feeds for different types of livestock. A study at the Ohio Station revealed that when pigs had abundant time to masticate their feed, as in the case of self-feeding, there was little difference in the rate of gain, or feed required per unit of gain, between whole grain and ground grain. However, with pigs that were fed grains ground to different degrees of fineness, or wet rations in troughs, or where the element of speed in eating, as in the competi-

tion at the trough, came into play, the results indicated that there may be an advantage in having a fairly uniform fine-ground grain. Under such conditions, the animals are likely to swallow a considerable portion of cracked material which will not be as thoroughly digested as the finer particles. When corn and barley of varying fineness were fed, there was no case where the finer grinding proved the best. Experiments at the Pennsylvania Station showed that fine, medium, and coarsely ground corn had an advantage over whole corn for swine. There was, however, no significant difference in the efficiency of the three degrees of fineness. The Wisconsin Station found that it was profitable to use a uniform grinding when barley was to be fed to pigs as a freshly made slop. When barley was self-fed, there was less advantage in uniform grinding, and with corn there apparently was no advantage at all.

In a study of the relative digestibility of whole and ground corn and the metabolizable energy content of each, the Illinois Station found that grinding to a medium degree of fineness increased the digestibility of the protein by 13 percent. Such grinding increased the digestibility of the gross energy only 2.8 percent and that of the metabolizable energy only 3.5 percent. The appreciable advantage in protein digestibility due to grinding was largely lost by greater losses of nitrogen occurring in metabolism, and the net effect on the nitrogen balance of the animal receiving an exclusive diet of corn was slight and inconsistent.

Soybean-oil meal as feed.—Since plant protein is a cheaper feed than protein of animal origin, attempts are being made to develop such protein feeds or to adapt those now in existence to rations for livestock. The Wisconsin Station found that properly prepared soybean-oil meal came about as near as any plant protein feed to equaling animal protein in pig rations. Soybean-oil meal produced at a temperature of 250° F. or above, when fortified with suitable minerals and bright, leafy alfalfa hay, was an efficient supplement to corn. Meal prepared in this manner had a light-brown color and a nutty flavor. It had the further advantage, when fed as above, of not producing soft pork. At the Missouri Station, a mixture of soybean-oil meal and tankage proved to be a highly valuable supplement to corn for fattening pigs. While animal proteins are undoubtedly better than vegetable proteins, especially for young pigs, the difference in price may make soybean-oil meal a more profitable purchase when it is necessary to buy a protein supplement.

Forage crops for swine.—While it has long been recognized that pasture was an excellent feed for swine, the actual part played by pasture plants in the nutrition of animals has not been known. The Missouri Station fed sows from weaning on a ration of yellow corn, tankage, linseed meal, alfalfa meal, cod-liver oil, and minerals. Pigs farrowed by these sows were usually normal at birth and for a few days afterward. From this time on, deaths that could not be attributed to starvation occurred until weaning time. Supplying the pigs with the juice of fresh, rapidly growing forages healed those that had developed paralysis and prevented the appearance of this condition in other animals. It was apparent that sows on defective rations secreted defective milk. Results obtained at the Ohio Station revealed that pigs on pasture gained about 0.25 pound more per head

daily and were ready for market 24 days earlier than similar pigs in dry lot. Green feed enabled pigs to make more efficient use of their grain and kept the animals in a healthy, vigorous condition. A suitable forage crop was palatable and succulent, low in fiber, and high in minerals and protein. Its worth was influenced by ease and cost of seeding, ability to produce new growth, remain green and withstand grazing, and adaptability to local conditions.

At the Oklahoma Panhandle Station, the use of Sudan grass pasture effected a saving of 11.6 percent in the cost of other feeds required to produce a unit of gain as compared with no pasture when fattening pigs were self-fed free choice on ground milo and tankage. A comparison of green rye and green barley as winter forages at the South Carolina Station showed that the barley was slightly more efficient in producing gains when used with a ration of yellow corn and fish meal than was the rye. The Louisiana Station found that sweetpotatoes must be hogged off at a later date than corn. Hogs going to market at the later dates usually sold on a declining market. This objectionable feature did not apply when hogs were being finished for home consumption.

Quality of pork.—In order to do away with much of the loss that occurs during the home curing of pork, the Alabama Station has made an intensive study of the problem. Hams kept in 75° brine for different lengths of time at constant temperatures of 36° and 85° F. showed definite spoilage when the meat was kept at a low temperature for only 1 week. All samples from hams kept at a low temperature for 2 weeks or longer were judged to be desirable in odor and flavor. Hams that were kept in brine for the longer periods rated higher. The Pennsylvania Station found that the salt in hams cured by various methods did not become uniformly distributed throughout the meat until approximately 60 days after the beginning of the cures. In brine curing, salt equalization was accompanied by absorption of salt from the brine until the meat was removed from it, after which salt equalization alone took place. In dry-cured hams, salt equalization began as soon as the last portion of the curing mixture was applied to the meat. With all the methods used, aging the hams for 30 days after removing from the cure permitted further equalization of the salt and gave a product of more uniform salt content.

Practical and reliable methods of modifying the quality of pork to meet particular consumer or packer demands were brought to light by experiments at the Illinois Station. It was demonstrated that the ratio of fat to protein in the body of a growing pig was in part, if not largely, determined by the protein content of the ration fed the animal. Within wide limits, the higher the level of protein feeding, the lower the proportion of fat to protein in the tissues produced during growth.

SHEEP

Fattening thin native lambs.—Results obtained in studies at the Maryland Station cooperating with the Department (B. A. I. and B. A. E.) showed that over a period of years it was possible for feeders to profitably feed thin native lambs of Low Medium and Cull grades. By following recommended feeding practices it was

possible to raise the grade of the lambs on the hoof from Cull and Low Medium to Good to Choice lambs. A ration composed of shelled corn, menhaden-fish meal, and clover hay produced rapid and economical gains. Peanut meal could be substituted for menhaden-fish meal or no protein supplement fed and the results would still be satisfactory. The increases in carcass weight resulting from feeding substantially improved the quality of the carcass. More fat was deposited in some cuts than in others, causing the percentage yield of some cuts to decrease with the increasing finish and quality of the carcass. The total physically separable lean increased in weight as a result of fattening, but tended to decrease in percentage as the feeding period progressed. The amount of edible material increased from 70.8 percent in Low Medium feeders to 77.8 in carcasses of lambs fed 102 days and to 79.3 in the carcasses of lambs fed 138 days. Of the major cuts, the loin showed the largest increase in weight, 117.8 percent. A comparison of the palatability of leg and shoulder roasts showed that on the average the shoulders were more tender and more juicy than the leg roasts. Shoulders and legs were about equal in desirability of flavor of lean and fat, and of aroma. The total cooking losses were greater for legs than for shoulders.

(See also pp. 108, 122.)

Sugar-beet byproducts for sheep.—Beet tops fed by pasturing without any supplementary feed made a highly satisfactory ration for fattening lambs at the Wyoming Station. Supplementing the beet tops with alfalfa hay produced faster gains. Adding barley improved the finish of the lambs but increased materially the cost of gains. Feeding cured beet tops to lambs in dry lot increased the rate of gain, but the cured tops were worth only about one-half as much as the pastured tops. Curing the tops extended their use over a longer period and insured against unfavorable pasturing weather.

The Montana Station found that oats and dried molasses-beet pulp were equal in feeding value when substituted for part of the alfalfa in a ration for wintering ewes. One hundred pounds of either oats or dried molasses-beet pulp replaced 222 pounds of alfalfa. Self-feeding fattening lambs on a ration of equal parts of oats and dried molasses-beet pulp by weight with alfalfa hay produced average daily gains of 0.43 pound per head over a period of 68 days. Similar lambs fed barley instead of the dried beet pulp gained only 0.27 pound per head per day.

Cross-breeding investigations.—Cross-breeding studies using native or grade ewes mated to purebred rams have been conducted at the California, Mississippi, and Wyoming Stations. In general, the results have shown that the breed of ram that gives best results depends on the type of offspring that is desired. If it is the object of the breeder to improve the quality of wool, rams of the Rambouillet or Corriedale breeds will give the best results. If the purpose is to improve the meat qualities, then rams of the Down breeds give better results. The results at the California Station showed that there was not enough market discrimination between weight and quality of carcass to permit choice Southdown cross-bred lambs to compete favorably with the larger, coarser crosses by Hampshire or Suffolk rams.

Breed differences in wool fibers.—The Oklahoma Station made a study of the physical characteristics of the wool fibers of different breeds of sheep. Length of fibers measured in millimeters averaged 63.2, 66.1, 81.6, 89.9, 93.9, and 109.3 for the Southdown, Rambouillet, Hampshire, Shropshire, Dorset, and Oxford breeds, respectively. The average number of crimps per inch was 10.8, 14.3, 8.0, 9.0, 6.8, and 7.0; the average stretch of fibers registered before breaking was 5.6, 6.1, 7.0, 6.9, 7.3, and 7.7 millimeters; while the average number of decigrams required to break fibers was 110.6, 71.0, 133.8, 130.9, 166.6, and 172.5, for the respective breeds. The correlation between diameter and stretch, and between length and stretch was positive in each breed. The same was true of the correlation between diameter and length for all breeds except the Dorset. The correlation between crimp and stretch, and between crimp and breaking strength was negative for all breeds. Sufficient difference was found in the characteristics of the fiber of each breed and between breeds to indicate that there was opportunity to improve the length of fleece, through selection, without danger of lowering the grade by too great an increase in coarseness of fiber.

Quality and quantity of mohair.—That the age of Angora goats had a marked influence on the weight of fleece and the diameter of fiber was shown in studies at the Texas Station. The influence of age was less marked on the length of staple, amount of kemp, and the face, neck, and belly covering. Males produced heavier and coarser fleeces with slightly shorter staple than females. Pregnancy and lactation lowered the weight of fleece and length of staple. No direct effect on diameter of fiber could be traced to pregnancy. Maximum fleece weight of females was reached at 3 years of age, while maximum body weight and diameter of fiber was not reached until 8 years of age. The maximum staple length was attained the first year, but the most mohair per pound of body weight was produced the second year. It was concluded that the most efficient production of the Angora goats was at 2 years of age, followed by a rapid decline with advancing age.

Effect of feeds on quality and palatability of lamb.—The use of wheat screenings or dockage containing many hard weed seeds in fattening rations for lambs resulted, in studies at the Montana Station, in flabby meat covered with a scant layer of greasy fat and having a peculiar flavor. Of the various weed seeds fed, the fanweed seed imparted the most objectionable flavor. When fed with alfalfa hay, oats were slightly superior to wheat and barley in producing roasts of good quality, juiciness, and general desirability. Barley appeared to consistently produce a rather greasy fat and a pronounced flavor in the lean. Adding wet beet pulp to a ration of wheat, barley, or oats and alfalfa hay improved the rate of gain and reduced the differences in palatability scores. Shrinkage during roasting was not appreciably altered by the ration fed or by the kind of cut roasted. (See also p. 122.)

POULTRY

Soybeans for poultry.—When ground soybeans replaced meat scrap in the laying ration of pullets at the Delaware Station, egg production was reduced, particularly when the soybeans exceeded 6.8 per-

cent of the ration. Soybeans were not as efficient in producing eggs as meat scrap and dried buttermilk, but had no detrimental effect on eggs in cold storage or on the hatchability. Ground soybeans were more effective in replacing meat scrap and dried milk in laying rations for hens that had completed their growth than for pullets in their first year of production. The Wisconsin Station reports that with poultry, as with pigs, soybean-oil meals manufactured at high temperatures are more valuable than those rendered at low temperatures. If soybean-oil meal is to be used in poultry rations, it should replace not more than 16 percent of the animal protein. Soybean hay or meal of good quality was as good as alfalfa hay, or meal of equal quality, when fed to laying hens, according to results obtained at the Ohio Station.

Oats for chickens.—The prevailing opinion that oats are a questionable feed for poultry was not borne out by experiments at the Ohio Station where oats were fed with advantage to chickens to the extent of 40 percent of the ration. Chickens in confinement readily ate whole oats, with practical elimination of feather picking, cannibalism, and pickouts previously experienced. The free-choice feeding of whole oats was used to advantage for chicks and pullets grown in confinement.

Chicks from hens' versus pullets' eggs.—The Texas Station finds that—

> eggs laid by pullets during the first year of egg production, even though the percentage of hatch is better, are not worth nearly so much for hatching as the eggs laid by hens after the first year of egg production has been completed.

The station found that fewer chicks from pullets' eggs survived to laying age and through the first laying year than of those from hens' eggs. Another important reason for using chicks from hens' eggs rather than those from pullets' eggs is that a means of identifying high producers is thus afforded.

Interior quality of eggs.—Considerable effort has been expended to discover what constitutes quality in reference to the contents of an egg, and to set up and standardize ways of improving and maintaining this quality at a high level. The New York (Cornell) Station found that there was a seasonal trend in the interior quality of fresh eggs laid by a flock of White Leghorns under practically constant management conditions. There was a lowering of quality beginning with March or April and continuing through the summer. Eggs of the highest quality were produced in the period between November and March. There was no seasonal change in the color of the yolks of hens' eggs. The interior quality of eggs was not appreciably changed by the amount and character of mineral supplements fed at the Illinois Station. The supplements used included sodium silicate, ground limestone, salt, magnesium oxide, and potassium carbonate.

A study was undertaken by the California Station to determine whether there was a real deterioration of eggs in summer prior to the time they are laid or if deterioration was the result of exposure to high temperatures after they are laid. It was found that egg weight was decreased by increased air temperature during the formation of the egg, but that the percentage of firm white and shell weight was not affected by air temperature during this period. The percent-

age of firm white was lowered by higher air temperature during the hours immediately after the egg was laid, resulting in an apparent seasonal variation in internal egg quality. The percentage of firm white did not depend in any way on the size of the egg.

Color and flavor of eggs.—Corn and dehydrated alfalfa had a pronounced effect on the yolk color of eggs at the Washington Station, although as a rule the amount of pigmentation in the yolks was not proportionate to the amount of pigment in the ration. The color changes induced by the ration began to take effect after the fourth or fifth day of feeding. The maximum color was reached in a period of 3 or 4 days after the pigment began to increase in the eggs. When rations were fed which induced less pigmentation than the preliminary egg-yolk color, the pigment disappeared gradually over a period of 14 days, after which pigmentation appeared to become stabilized. The Oklahoma Station in studying the effect of feeds and various environmental conditions on the quality of eggs found that garlic, onions, and cod-liver oil impaired the flavor. Certain green feeds, weeds, and other feedstuffs caused discolored yolks in some cases, but chopped rape had no effect on yolk color either before or after storage. Highly pigmented feeds, such as green alfalfa and yellow corn meal, changed the color of yolks from light yellow to dark orange. Rations containing 30 percent of linseed meal or soybean-oil meal as the sole protein supplement produced discolored yolks, while peanut meal and corn-gluten meal had no such effect.

Effect of packing material on flavor of eggs.—From a comparison of the effect of news pulp, strawboard, spruce, excelsior, willow, jack pine, and aspen packing materials on the flavor of eggs, the New York (Cornell) Station concluded that spruce fillers imparted the least flavor to the eggs and strawboard fillers the most. This was not always true, for at times strawboard was just as good as spruce. The same packing material made by the same manufacturer may differ in its taste-producing results from year to year. Humidity heightened the crate flavor for some materials and slowed it down for others. To impart a flavor to an egg, the packing material must contain a compound that evaporates readily into the air and permeates the shell of the egg. Sometimes the compound itself gives the new flavor to the egg, but even if it is tasteless, the compound may cause the egg to develop a new taste by setting up a chemical reaction in the egg.

Some factors affecting storage quality of eggs.—According to results obtained at the Arkansas Station, it was not safe to include more than 5 percent of cottonseed meal in the laying ration if the eggs produced are to be held in storage longer than 3 weeks. Green feed had no influence on the storage quality of eggs if a balanced diet was available to laying birds in addition to the green feed supplement. The Iowa Station found that levels of protein supplement ranging from 0 to 15 percent in the rations of hens did not influence the loss of weight or interior quality of eggs during storage. There was no difference in loss of weight during storage between eggs produced in late winter, spring, or early summer when they were held at approximately the same temperature before storage. Loss of

weight during storage was reduced by storing only eggs with shells of slight apparent porosity.

Seasonal growth and feed consumption of turkeys.—Weights of Bronze turkeys taken at 4-week intervals at the California Station from the time they were hatched until 32 weeks of age showed that the earlier hatched birds grew more rapidly for a period of 8 or more weeks and were significantly heavier at 4, 8, and 12 weeks of age than later hatched poults. At 32 weeks of age, there was no significant difference in the weights of the various groups of females, but the earlier hatched males were still heavier than the later hatched males. Lower outside temperatures, particularly during the first few weeks, appeared to result in increased rate of growth. Humidity did not apparently affect growth, although continuous rain retarded growth. The amount of feed consumed varied directly with the amount of gain for at least the first 16 to 20 weeks. The amount of feed per unit of gain increased with age in all cases.

Selecting breeder turkeys.—At both the California and Pennsylvania Stations it was found that the egg production of turkey hens decreased materially after the first year. The first station found that the fertility of eggs did not change significantly with age, but hatchability decreased after the second laying year. Eggs laid in the second year were larger than those laid in the first laying year and poults from 2-year-old hens were larger at hatching time than those from 1-year-old hens. However, at 16 weeks of age there was no significant difference in weight. There was slightly higher mortality in the progeny of 1-year-old hens than in the progeny of 2-year-old hens, but this did not offset the larger average number of poults hatched from the younger hens.

Incubating turkey eggs.—The proper method of artificial incubation of turkey eggs is still a question of great importance. The Idaho Station reported that a condition of high humidity during the period of actual pipping and hatching was essential. The Kentucky Station found three distinct embryo growth phases with a definite retardation starting on the ninth and nineteenth days. This led to the conclusion that incubation practices which tend to increase hatchability in chicken eggs should produce similar favorable results with turkey eggs. Studies at the North Dakota Station showed a progressive, significant increase in hatchability with temperatures of 100°, 101°, and 102° F. At the New York (Cornell) Station, hatchability of turkey eggs was satisfactory at temperatures of 96.8° to 106.7°. Hatchability declined at temperatures above or below this range, and the decline was greater at the higher temperatures. The vigor and growth of the poults was greatest when hatched at the above temperatures rather than at higher or lower temperatures.

Nesting habits of ring-necked pheasants.—The average size of completed clutches of ring-necked pheasants was 11.2 eggs in nests under observation at the Iowa Station. A decline in the number of eggs per clutch with the advance of the nesting season was observed. The nesting season extended from early April through early September, but the majority of the clutches were begun in the period from late April through early June. Of the nests observed, 76.9 percent were failures. The causes of failure were as follows: Man,

52.3 percent; predators, 19.3; abandonment of unsatisfactory sites, damp nests, and infertile clutches, 3.5; flooding, 5.8; nests totally lacking in cover, 0.9; and unexplained, 18.1 percent.

ANIMAL DISEASES AND DISORDERS

The prevention of the spread of animal diseases and the curing of sick animals has become an increasingly important problem. The concentration of livestock, the exchange of animals between farms, and the visits of persons from one farm to another have all increased the possibilities of the spread of disease. Medication and treatment are the first steps in combating disease, but in order to cope adequately with a disease it is necessary to know more about the nature and habits of the causative organism. With such basic information, measures can be devised for killing the organism before it can gain entrance to the animal body or for attacking it at its weakest point during the course of the disease. The stations report gratifying success in securing information of this kind. Some examples of recent station work, having in view a fuller scientific knowledge of animal diseases and disorders, follow.

HORSES

Cornstalk disease.—An outbreak of the so-called cornstalk disease of horses, also known as toxic encephalitis, nonvirus encephalomyelitis, staggers, and forage poisoning, in central Illinois in 1934–35, that was investigated by the Illinois Station caused a loss of some 5,000 animals. The disease developed in horses browsing on cornstalks or eating corn which had been stored in too damp a condition. Animal inoculations failed to reveal the presence of a virus or virus-like agent. A similar disease was studied by the Indiana Station. The microscopic changes found indicated an infectious agent as the cause. Its relation to encephalomyelitis remained to be determined.

CATTLE

Mastitis of dairy cows.—Comparative diagnostic tests at the Virginia Station led to the conclusion that physical examination compares very favorably with other methods in the diagnosis of mastitis. Bromocresol purple-impregnated paper was found especially valuable when used in conjunction with the physical examination. The strip-cup and rennet tests are simple and reliable for use by the dairyman. The Wisconsin Station described a new milk test with fresh commercial fluid rennet for the detection of mastitis which, because of its simplicity and cheapness, may have practical use. Subclinical mastitis causes the milk to have a lower curd strength and to coagulate more slowly with rennet. Studies of freshly isolated and stock strains of the mastitis streptococcus by the New York State Station indicated that the majority of those associated with the ordinary bovine mastitis are of one general type, for which the name *Streptococcus agalactiae* should be used. Udder strains of the nonhemolytic (alpha) group of *S. agalactiae* commonly associated with bovine mastitis were found by the Wisconsin Station to be identical and remarkably constant in their biological characters.

Bang's disease or infectious abortion (brucellosis).—A study conducted by the Michigan Station indicated that the udders of heifers may become infected with *Brucella abortus* as early as 8 months of age and that changes may occur in nonlactating udders. Abortions may occur in herds after Bang's disease has apparently been brought under control, according to that station. In three herds free from Bang's disease the station observed an abortion rate of 5.4 percent. Various causes for such abortions are indicated by the station, such as previous severe illness, faulty nutrition, and perhaps occasional direct injury. Of a number of cows in contact with infected swine for a period of 27 months, only one case developed abortion, in observations reported by the Missouri Station. The station concluded that "the swine organism is but slightly pathogenic for cattle when the cattle are exposed to infection by close contact with the infected swine."

The Connecticut (Storrs) Station reported a well-authenticated case of transmission of Bang's disease to dairy cattle by horses, and suggested that horses as well as cows should be blood-tested for Bang's disease when there is any possibility of their coming into direct contact.

In a study by the California Station of a herd of dairy cattle in which 19 percent of the animals were infected with *Brucella abortus* it was found that recovery from the disease is rare in the average life of a cow. Cows with a definite and long-standing positive blood history cannot safely be given a clean bill of health after a few negative tests. Complete removal from the herd of all cows that show agglutinins in 1–50 was the only type of segregation that prevented the spread of the disease in this herd. The infectious abortion organism was isolated by animal inoculations at the Illinois Station from 50 percent of raw-milk samples collected at milk depots in 28 widely scattered counties of the State. Pasteurization as employed in five different types of pasteurizers was found to effectively destroy the organism. In investigations reported by the Maryland Station the average milk production of noninfected cows during a 4-year period was 6,844 pounds per year with a butterfat content of 281.6 pounds per negative (noninfected) cow as compared with 6,330 pounds of milk and 251.6 pounds of fat per positive cow. The calvings were at the rate of 1.07 per cow-year in the noninfected group and 0.86 percent per cow-year for the infected group.

The results of a cooperative study by the Department of Agriculture and the Wisconsin Station showed that the serum of bovine blood normally contained bactericidins for *Brucella abortus*. Whole blood showed a bactericidal effect slightly less than comparable amounts of serum alone. There was a marked difference between individual animals in bactericidal activity. Certain animals recovered from a previous infection of *B. abortus* showed a loss in bactericidal properties of the whole blood as compared to that of presumably normal animals. The South Carolina Station, cooperating with the Department, reports promising results in an attempt to find individual cows showing hereditary resistance to infectious abortion. Individual cows were found whose blood showed a high killing power for the abortion organism. The findings in a study of in-

heritance of immunity to Bang's disease by the same station indicate that the blood of certain families of dairy cattle has the power to kill the organism causing this disease.

Fetal pneumonia of calves.—Calf pneumonia is a rather common and troublesome problem with many breeders. The Michigan Station finds that the disease is especially prevalent in animals affected by Bang's disease, and suggests that the presence of well-marked pneumonia in calves 1 to 10 days old strongly suggests prenatal infection.

Anaplasmosis of cattle.—The Louisiana Station finds that anaplasmosis is becoming more common in Louisiana and that livestock owners are becoming more conscious of its importance. The station observed that cases of anaplasmosis are very rare in the State from November 1 until about April 15 to May 1, indicating that some carrier agent which is inactive during the late fall, winter, and early spring may be responsible for the spread of the disease. The generally sporadic nature of the cases indicates that the disease possesses a very low degree of contagiousness or ability to spread. On the other hand, it does at times occur in a large number of animals in a herd, acting like a highly contagious disease. Observations by the California Station indicate that *Dermacentor occidentalis*, the western dog tick, is an important carrier of anaplasmosis in California, probably the most important of all. It is a widely distributed and abundant tick in that State, having a wide host range, and is frequently found in all stages except larvae on cattle and deer. The latter, a proven carrier of anaplasmosis, may be responsible for some outbreaks.

Hemorrhagic septicemia.—The causal organism of hemorrhagic septicemia, *Pasteurella boviseptica*, was isolated by the Florida Station from calves affected with bronchopneumonia. It has also been isolated from calves infected with joint ill.

The prevention of maggot infestation of wounds.—In experiments conducted by the California Station, open wounds in cattle, sheep, horses, and hogs were satisfactorily protected against flesh flies by the application of bone oil. In no case where bone oil was applied after the removal of screwworms from infested wounds was there reinfestation, and healing was exceptionally rapid, showing no detrimental effect of the bone oil on the tissue.

Loss from flies.—It was shown by the California Station that the loss in milk production from heavy infestations of houseflies and horn flies was negligible, while that caused by stable flies was slightly less than 10 percent. Fly sprays of petroleum oils carrying pyrethrum or pine oil, or both, had the same repellent efficiency for the first hour but differed at subsequent intervals, pine oil increasing in efficiency in proportion to the amount added. A water emulsion of pyrethrum and pine oil combined with a small amount of petroleum was as efficient in controlling flies as the petroleum sprays and was less detrimental to the cows. The Maryland Station found pyrethrum and derris dust mixtures to be effective in protecting cattle from flies, owing to their toxic rather than their repellent properties. Because of their blood-sucking propensities, horseflies may be the cause of considerable losses to farmers and dairymen in Delaware, as well as being responsible for the transmission of anthrax and anaplasmosis of

cattle. Information concerning the distribution, seasonal abundance, and biology of more than 40 local species has been secured by the Delaware Station as a basis for the development of effective measures for their control. Pine oil was found to increase materially the repellent effect of pyrethrum and derris extracts. When added at the rate of 1 pound per gallon of extract, there was no skin injury from the use of oil spray. The station concludes that pine oil may be safely and economically employed in practical cattle fly-spray formulas.

Pathology of rickets in dairy calves.—The changes found in low vitamin D rickets in dairy calves at the Michigan Station were always preceded by decreased concentrations of calcium and of inorganic phosphorus in the blood plasma. Histological changes were confined largely to a relatively small portion of the bone at the costochondral junction. Retarded provisional calcification of the cartilage matrix appeared to be the fundamental change in rickets. The most conspicuous changes in microscopic study were irregular removal of cartilage by the embryonic marrow and the accumulation of excess osteoid tissue. Growth was an important modifying factor in rickets, the more severe cases being associated with more rapid growth (p. 94).

Toxicity of thallium sulphate for cattle.—The Colorado Station found that after fasting for 24 hours some cattle will take thallium sulphate-poisoned oats, such as are used to destroy rodents, in sufficient quantity to cause death in from 4 to 13 days.

SHEEP AND GOATS

Dysentery in lambs.—A study by the Montana Station of the etiology of dysentery in newborn lambs has led to the conclusion that the disease is the result of several factors. Chief among these are pathogenic strains of species of bacteria normally present in the intestines which are ingested with filth, due to unsanitary conditions in corrals and sheds, and on the udders of ewes. The infections occur when the resistance of the lambs is lowered by cold and wet environment.

Pregnancy disease.—In a study of pregnancy disease of sheep, the North Dakota Station has established that this trouble is a carbohydrate and not a mineral nutrition problem. Experimental ewes developed characteristic fatty livers even though fed mineral supplements. The livers of the newborn lambs showed a higher glycogen content than those of the parent ewes, suggesting an increased nutritional demand of metabolism in advanced pregnancy.

Internal parasites.—The internal parasite problem of sheep apparently is being solved by the Florida Station by proper rotation of permanent and temporary grazing areas. In experiments on mass feeding of sheep with copper sulphate and salt to control such parasites, the West Virginia Station found that a mixture of copper sulphate and salt, 1:30, fed to sheep ad libitum and consumed at the rate of one-half pound per sheep per month did not adequately control the development of roundworm parasites in the gastrointestinal tract and caused the death of the sheep from poisoning. A 1.5-percent solution of copper sulphate and a mixture of equal parts of a 1.5-percent solution of copper sulphate and a 1.5-percent solution of nicotine sulphate were equally efficient in the control of roundworm

infestation. Tapeworm infestation also disappeared under the two treatments.

Prevention of death losses on areas infested with pingue.—The New Mexico Station demonstrated that the heavy death losses of range sheep caused by feeding on pingue, or the Colorado rubber plant, can be reduced, if not entirely avoided, by managing the sheep in such a manner that they enter pingue areas in at least fairly good physical condition after lambing. Loss of sheep from the poisoning and injury to the range by premature grazing are both avoided by the bedding-out system of grazing sheep whereby a new bed ground is established every night or every 2 or 3 days in choice areas of forage.

Grubs in the head.—"For many years", says the Idaho Station, "research workers and sheepmen have been of the opinion that the small maggots (larvae) deposited in the nostrils of the sheep by the [gad] fly required 8 or 10 months for development before they were discharged." The Idaho Station, cooperating with the Department (B. A. I.), has found that the minute larvae remain in the nasal passage without growing during the winter months and that only those larvae that had migrated back into the sinuses developed during the winter. The station has shown, however, that the minute larvae can become full grown in a period of 33 days during warm weather. "External temperature, then, would appear to be the controlling factor in the rate of development of larvae of the sheep gadfly", and the station suggests the advantage of destroying the larvae as found in the nasal passage during the winter season.

The pathology of blind staggers and alkali disease.—Data obtained from autopsies at the Wyoming Station of cattle and sheep suffering from blind staggers and alkali disease indicated that the toxic principles of both types of injury had very similar physiological actions. The toxicant was acutely toxic to the liver cell. Blind staggers represents a more acute type of poisoning, while kidney injury was more severe in alkali disease. Sheep suffer more from this injury than do cattle. Enlarged gall bladders are common in blind staggers, but only occasionally observed in alkali disease. The heart is invariably atrophied in severe cases of alkali disease. Injury to the gastrointestinal tract in blind staggers consisted of irritation leading to hemorrhage and finally the scaling off of the epithelium. In alkali disease the injury was of the same character but milder. The hearts and livers of animals suffering from an acute severe attack of blind staggers rapidly become permanently injured. Younger animals appear runty and, due to distended stomachs, seem to be bloated chronically. Abnormal hoof growths were characteristic of alkali disease only. While erosion of the ends of the long bones was common in both ailments, it was more prevalent in alkali disease. The color and condition of the coat in poisoned cattle were in a measure diagnostic aids in recognizing this type of injury. Affected sheep had a characteristic stance and appearance. Although it was believed that blind staggers and alkali disease were produced by the same causative agents, there was enough difference in the appearance and symptoms exhibited by affected livestock to retain the two terms. On the other hand, the microscopic pathology hardly justifies the designation of two different types of intoxication.

Tuberculosis in milk goats.—It is commonly believed that goats possess a high degree of immunity to tuberculosis. The New Mexico Station, however, shows after many years' testing of the station herd that although the percentage of tuberculous reactors in the herd has been very small as compared with the number found in many dairy herds, goats are not entirely immune from tuberculosis.

SWINE

Vesicular exanthema.—A foot-and-mouth-like disease appearing among garbage-fed swine in California, to which the name vesicular exanthema has been given, was studied by the California Station with reference to finding a more effective means of diagnosis and control. The station concludes that the disease cannot safely be differentiated from foot-and-mouth disease without the aid of animal tests and recommends that, in the absence of a reliable diagnosis, infected animals be slaughtered and infected premises be cleansed and disinfected without resort to drastic quarantines.

Intestinal emphysema.—In experiments conducted by the Iowa Station, the intestinal emphysema met with in swine was shown to be associated with the feeding of polished rice. Cases of this affection were encountered in several groups of chickens on a test ration containing rice. When corn was fed to swine with as much as 20 percent of skim-milk powder by dry weight, the emphysema failed to develop.

Pathology of avitaminosis A.—Microscopic examination of the spinal cord and sciatic nerves of hogs suffering from a deficiency of vitamin A at the Missouri Station showed unmistakable evidence of a fatty change or a myelin degeneration when the examination was made shortly after the first symptoms of incoordination developed. After several weeks had elapsed it was not possible to demonstrate the fatty change when employing the same technique, even though the animals showed external symptoms of deficiency. The most characteristic symptoms of this deficiency were diarrhea, emaciation, muscular incoordination, blindness, dermatitis, intense itching, and in white hogs a marked pink color of the skin. Resistance to secondary infections was greatly lowered.

POULTRY

Coccidiosis.—Coccidiosis, because of the mortality it causes among growing chicks and the reduction in egg production of pullets that recover from the disease, has been one of the primary causes of worry to producers. A recent contribution that seems to offer great possibilities for assisting poultrymen to overcome one of their most serious sources of loss has been made by the Wisconsin Station. This station has found the addition of flowers of sulphur to hopper-fed dry mash 4 days before infection to be effective not only in reducing but in preventing the effects of coccidia in chickens. When 20 percent of sulphur was fed for a period of 6 days there was a reduction of the severity of the lesions and no mortality from an infection of coccidiosis which was fatal to 70 percent of the chickens that were not given sulphur. The feeding of 10 percent of sulphur, although preventing visible lesions in one-third of those treated, did not pre-

vent all mortality. There was no evidence that the administration of sulphur had any curative effect on coccidiosis in poultry after the infection had become established.

From results of a study of resistance of chickens to the causative parasite, *Eimeria tenella*, the station concluded that chickens of all ages up to and including 15 months are susceptible to infection with the parasite and show symptoms of acute coccidiosis following infection. Chickens infected when 3 months old or older are considerably more resistant to the effects of *E. tenella* than are chickens infected when not over 2 months old. Chickens infected with cecal coccidiosis were found to be carriers of the organism for 7½ months, as indicated by viable oocysts in the cecal droppings.

The Missouri Station reports that brooding chicks on clean range is a practical preventive of coccidiosis. If infection occurs, steps should be taken at once to confine the disease to the smallest number of chicks and to reduce loss by feeding a ration which contains a high percentage of milk in some form in addition to reduced feeding of other feeds and the following of a strict sanitation program. The station recommends that after an outbreak of the disease the brooder house should be thoroughly cleaned and disinfected, with frequent changes of litter or litter substitutes. A good disinfectant should be used in the drinking water. It is important that the chicks be moved to new, clean ground after recovery in order to reduce the chances of reinfection.

Pullorum disease.—The whole-blood agglutination test for pullorum disease has been found by the Massachusetts Station to be less reliable than the standard tube test that has been used in the control work in that State. The station says that while the whole-blood test may be useful in reducing the amount of infection under some conditions, its adoption is not recommended where the establishment of pullorum disease-free flocks is the goal. A comparison of the several tests for detection of pullorum disease led the Mississippi Station to conclude that the rapid blood-drop method is practical and efficient under field conditions in that State and more economical in time, labor, and money than the tube and rapid serum tests.

The Michigan Station found that there was a much higher incidence of the pullorum disease organism in both dead embryos and chicks dead in the shell from hens reacting to the test for pullorum disease than in live chicks from the same hens. Since the percentage of infection shown by chicks hatched from reactor hens is remarkably low, it is concluded that the extent of the disease in the chicks is probably due not to the large number of infected chicks hatched but to the spread from a few infected chicks during hatching and brooding.

Arthritis in a chick was found by the New Jersey Station to be caused by the pullorum disease organism, which may occur as a localized infection in many of the organs and tissues of the body. In the control work with pullorum disease, an average infection of but 0.3 percent was found by the Massachusetts Station in blood tests of flocks in 11 counties, this being the lowest obtained in the work that has been under way for 16 years. In two of the counties none of the birds tested was found infected.

Fowl pox.—In work at the Kansas Station, the virus of fowl pox was passed through eight series of fowl eggs without significant alteration in virulence for developing eggs or chickens of several ages. Vaccination against fowl pox is being used to an increasing extent by the New Jersey poultrymen with marked decrease of mortality, the New Jersey Station finds. In a recent study by the station it was found that more than 50 percent of the poultrymen reporting vaccinated their flocks. A very large proportion use the stick method of vaccination recommended by the station, applying the method to birds between 8 and 12 weeks of age. In preliminary experimental work at the California Station the vaccination take in day-old chicks was shown to be accompanied by a systematic reaction which under unfavorable conditions may contribute to excessive mortality.

Respiratory diseases.—A committee on poultry diseases, which included representatives from the Kansas, Michigan, New Jersey, and California Stations, was led to recommend the recognition of three distinct respiratory affections of the fowl, namely, (1) infectious laryngotracheitis, a virus disease; (2) fowl coryza, a disease primarily of the upper respiratory passages, sometimes involving the head and lower respiratory tract, caused by a specific hemophilic bacillus now known as *Hemophilus gallinarum;* and (3) infectious bronchitis, a new disease, immunologically distinct from laryngotracheitis, affecting primarily the lower respiratory tract, but sometimes involving the respiratory passages of the head.

Filtration studies of the respiratory diseases of the fowl by the Massachusetts Station led to an improved technique that should find extensive laboratory use in work with the filtrable viruses. For reducing losses due to laryngotracheitis of poultry, the same station proposes two procedures:

> In regions in which the disease is not very prevalent the eradication and control plan should receive first choice. In other places in which it has existed for a long time and practically all of the flocks are affected, one may resort to vaccination.

Discussing the relation of laryngotracheitis to common colds, the station says:

> While it is impossible to do much with colds at the present time, the situation in regard to laryngotracheitis is different. We have the scientific means for controlling this disease.

The virus of infectious laryngotracheitis of fowl was propagated through 35 series of developing chicken eggs by the Kansas Station without significant modification in virulence. Of the species of developing eggs other than chickens, only those of the turkey were susceptible to laryngotracheitis infection. Work at the California Station led to the conclusion that chickens cease to be virus carriers about 1 week after vaccination against laryngotracheitis. The Rhode Island Station developed a technique for and isolated *Hemophilus gallinarum* in pure cultures from the edematous swellings of fowls showing infectious coryza and demonstrated that the success of such isolation depends on the length of time the swellings have persisted.

Fowl paralysis and leukemia.—The Florida Station finds that fowl paralysis and leukemia, as well as a number of conditions associated with these diseases in naturally occurring outbreaks, are caused by

the same agents, namely, certain bacteria of the paratyphoid and typhoid groups. Birds exposed to parasites and allowed to develop chronic inflammation of the intestinal tract were much more subject to paralysis and leukemia than those protected from such infestation. The parasites appear to interfere with the normal intestinal flora and allow the organisms of the typhoid and paratyphoid groups to become established in the intestinal tract. Birds kept free from parasites until 6 weeks old failed to develop fowl paralysis when subjected to infection by the causal organisms over a period of 30 to 60 days. That fowl paralysis is readily transmitted by pen contact from affected to nonaffected chicks and that the disease develops to a less extent in chicks from an affected flock than those from a nonaffected flock when brooded together was established by the Idaho Station. The disease was shown to be more prevalent in chicks from pullet breeding stock than in those from hen breeding stock from the same affected flock. Evidence of variation in inherited resistance was apparent in different families. A study by the Iowa Station of the egg as a possible mode of transmission of range paralysis in chickens furnished no evidence of an inherited tendency to the disease. Embryonic examinations at various stages of incubation failed to indicate direct transmission through the egg, but results of breeding experiments have given some indication of limited transmission through the egg. An antiserum has been prepared by the Florida Station which has proved effective in curing 83 percent of uncomplicated cases of leukemia in the fowl. That heredity plays a very important role in the degree of resistance and susceptibility of chicks to fowl leukosis and is of great importance in the control of the disease was shown in work at the Iowa Station.

Lymphomatosis and fowl paralysis.—Findings at the Minnesota Station support the view that lymphocytoma and fowl paralysis are two separate diseases, the latter being transmissible, the former nontransmissible. The two diseases may coexist in the same bird, and data obtained suggested that heredity is a factor to be considered in their transmission.

Paratyphoid disease of turkey poults.—A paratyphoid organism isolated from turkey poults of various ages under 5 weeks from farms widely distributed in Iowa, where large losses were experienced in 1934, was identified by the Iowa Station as a form of *Salmonella aertrycke*. Experiments demonstrated that the organism is highly virulent for baby chicks, young poults, guinea pigs, and rabbits. A similar affection was found by the Idaho Station to be responsible for the loss of practically all of 12,000 poults hatched on one farm in Idaho in the spring of 1935. Attempts by the station to prevent the excessive losses caused by the disease were not encouraging.

Mortality in young turkeys.—Evidence was obtained by the California Station that trichomonads of an undetermined species may play an important part in the heavy mortality from enteritis that has been found to be associated with the presence of these flagellates in the digestive tract.

Acute swine erysipelas infection in turkeys.—An outbreak of disease in a flock of some 500 turkeys in which over 200 died within 9 days was shown by the New Jersey Station to be caused by an organism indistinguishable from that of swine erysipelas.

A Salmonella disease of baby quail.—A high mortality in baby quail at a game farm in Illinois during the summer of 1935 was shown by the Illinois Station to be due to an organism resembling *Salmonella newport.*

GENERAL

Immunization against virus diseases.—The California Station called particular attention to the fact that while in the immunization against virus diseases the serum-simultaneous method produces a superior type of immunity, the tissue vaccine is infinitely safer and should safely control losses from virus infections and assist in eradicating virus scourges.

A vector of relapsing fever.—A new species of tick, *Ornithodorus hermsi*, which enters cottages, has been found by the University of California in nests of chipmunks at elevations of about 5,000 to 8,000 feet, and has proven to be a carrier of relapsing fever.

Plants poisonous to livestock.—After repeated feeding trials with negative results, the Texas Station finally found that broomweed (*Gutierrezia microcephala*) is distinctly toxic for sheep, cattle, and goats, thus, in a measure, confirming ranchers' opinion on the subject. "Fatal results were produced in sheep by feeding 8 pounds of the plant during a period of 5 days, in a steer by feeding 24 pounds in 3 days, and in a goat by feeding 11 pounds in 14 days." No evidence was obtained that the plant is responsible for abortions in cattle, as is the common opinion among ranchers of the Southwest. As a rule, losses due to this plant are sporadic and occur as a result of unfavorable ranch conditions, which reduce the supply of other good forage plants. Losses are especially large during periods of drought. The station reports a study of highly fatal poisoning among range sheep and cattle, resulting from the eating of the buds, green shoots, and young leaves of the common shin oak (*Quercus breviloba*), and while it states that no efficient means of treatment has been found, other measures, mostly of a preventive nature, are suggested.

Poisoning of range sheep, goats, and cattle from eating green leaves of mescalbean (*Sophora secundiflora*) is also reported.

> The experimental feeding tests showed that the poison in the leaves varies to a large extent with the season of the year, the mature fall and winter leaves being much more toxic than the young leaves during the spring months. * * * There is reason to believe that the supplemental feeding of range animals during periods of short range will prevent any occurrence of this poisoning. In pastures in which the tree is not too abundant, eradication by chopping the tree and grubbing the roots is practical at a relatively low cost.

African rue (*Peganum harmala* L.) has been found by the New Mexico Station to be poisonous to cattle and sheep under certain conditions. Because of its unpalatability, however, it is eaten by cattle and sheep only when the animals are in a starving condition. It is less difficult to induce sheep to eat it than cattle.

> The unpalatability of the plant was reduced by drying. However, cattle and sheep refused to eat hay made of it when the hay was kept in a feed lot before them for several days. Although African rue endures drought exceedingly well, it would seem best not to introduce it into new areas nor to encourage or permit the spread of the present stand.

The timber milk vetch (*Astragalus hylophilus*) has been shown by the Colorado Station to be the cause of—

> a chronic disease of cattle developing in the late summer and manifesting itself mostly in lactating animals. * * * The more prominent symptoms are incoordination of gait, weaving, clicking the heels together, emaciation, weakness, husky voice, the urine passed in spurts on driving, and finally paralysis and death.

It is stated that it is very doubtful that any medicinal treatment is of value. Since the vetch usually dries up in Colorado about the last of August and is then harmless, it seems feasible to pasture the worst-infested areas after that time. Good feed and good care would bring some of the poisoned animals through and allow them to be slaughtered for meat. The worst should be killed early to save feed.

The Minnesota Station failed in 3 years' feeding experiments to demonstrate the toxic properties of Sudan grass and other plants which appear capable under certain conditions of generating highly poisonous cyanogen compounds.

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FOODS, HUMAN NUTRITION, AND PROBLEMS RELATED TO THE HOME

Connected with nearly every farm in the country is a farm home which furnishes the incentive to carry on farming as an occupation. The large agricultural problems dealt with in this report are chiefly those of production—better farm crops, improved livestock, more scientific management of agricultural resources. At the same time the agricultural experiment stations are interested in the equally important problems of the home—better foods for human consumption, improved nutrition of human beings, and better management of the resources available to the farm family—resources which should increase with improved farm practices and consequent increase of farm income. Some of the contributions of the experiment stations during the yast year of direct benefit to the home and its members are noted below.

FOOD PREPARATION

As has been noted in earlier reports, food-preparation studies at the experiment stations vary from the routine cooking tests according to standard methods for quality judging to fundamental research into the principles of certain processes. The routine testing in the first type of study calls for the development of the best possible methods to detect slight differences in quality, and these are often adopted as improved methods in home practices. The second type of study may make even more of a contribution to the home through revolutionizing certain practices and introducing entirely new methods.

Meat cookery.—The cooking committee of the cooperative meat investigations, which includes in its membership representatives from the Iowa, Kansas, Minnesota, Missouri, and North Dakota Ex-

periment Stations, has been responsible, collectively or individually, for introducing a number of changes in meat-cooking methods. One of these is the household use of a meat thermometer to remove all question of whether the roast has been cooked to the rare, medium, or well-done stage. Fifteen years ago meat thermometers were practically unknown outside of the food research laboratory. Now they are sold by the hundreds to up-to-date housewives. Another change in practice now being recommended by some of the committee members is the cooking of a roast at a constant rather low temperature, instead of searing it at a high temperature and completing the roasting at a lower temperature. Another change is in the greater use of an open pan with rack and no water rather than a covered pan for most roasts.

The Missouri Station, one of the first to test the constant-temperature method, now recommends it definitely in preference to the searing method, for well-finished cuts of meat. A constant oven temperature of 150° C. (302° F.) is recommended for beef rib and leg of lamb roasts, and 175° C. (347° F.) for pork loin. Higher oven temperatures were found to decrease the cooking time but to increase the cooking losses and fuel consumption, and consequently the cost per serving of the meat. The Missouri Station has also been applying the constant oven-temperature method to less tender cuts of U. S. Medium grade beef. As a result of many comparisons of pairs of cuts cooked in different ways, the station recommends the following methods for cuts of this description:

A low constant oven temperature of 150° C.; a meat thermometer should be used rather than time per pound method; top round cuts should be cooked by true roasting (no water and uncovered) to a final internal temperature of 62° C.; heel-of-round cuts should be cooked in covered pans (moist heat) to a final internal temperature of 85° to 95° C.; and drippings from the cuts, particularly those cooked by moist heat, should be used in a gravy and served with the meat to enhance the flavor, increase the juiciness, and save the food nutrients.

In comparative tests of constant oven temperatures of 125° and 225° C. in the cooking of beef and ham to the well-done stage, the Texas Station found that the lower temperature produced a more tender roast than the higher in 95 percent of the tests with chuck, 90 percent with rump, 65 percent with ribs of beef, and 65 percent with ham. In these comparisons the meat-judging committee at the station used not only a method of scoring similar to that of the meat investigations committee, but also a slightly different method developed at the station and known as the paired eating method. In this method identical cuts from the right and left sides of the animal are roasted at the two oven temperatures to the same internal temperature, after which paired slices are taken from the center of the roasts and these are further cut into paired strips and each strip into small samples about ¼ by ½ by ½ inches. The paired samples are then compared for tenderness on eating. This method is recommended as particularly satisfactory for comparing the effect of one cooking factor upon one quality, but with the caution that it "cannot be used for comparing a large number of individual roasts with each other, nor for comparing individual roasts cooked on different days."

Veal cookery has received considerable attention at the North Dakota Station. The standard method first adopted for veal in the

meat-judging work of the cooperative meat investigations was searing at 275° C. for 20 minutes followed by slow cooking in a covered roaster at 125° to an internal temperature of 71°. The station has found, however, that roasting in an open pan at a constant temperature of 150° to 175° to an internal temperature of 74° gives much better results. The color of the roasts is said to be a deep reddish brown and the aroma and flavor pronounced and desirable. The total cooking losses are less than in the searing method, although the time per pound is 3 to 5 minutes longer.

The North Dakota Station has also studied the economy of different veal cuts in relation to waste in cooking and serving, and the number of servings to 1 pound of raw meat. Although the waste in fat and gristle is small in veal cuts, the relative proportion of bone to meat and the losses on cooking are large. Records of the number of servings from various cuts in the college cafeteria showed the center thigh cut to yield approximately four servings of sliceable meat per pound of raw meat, as compared to somewhat more than two servings from the whole leg and two from the shoulder cuts. The neck, when used for stews, gave the largest number of servings per pound of raw meat.

The station recommends surface-burner cooking of small or less tender cuts of beef, veal, and pork in the Dutch oven or drip-drop kettle, as saving approximately seven-eighths of the fuel used in oven roasting. When this method is used the drippings should always be saved for gravy. Leaving the cover off the kettle during part or all of the cooking gives a product more nearly like an oven roast in exterior color and aroma.

Juiciness is one of the important qualities of a good roast, particularly beef, unless a very well-done roast is desired. What changes take place in cooking to different degrees of doneness as determined by internal temperatures? The Minnesota Station has made an attempt to answer this question by extracting the juices from roasts of the eye muscle of bottom round of Choice quality beef cooked to internal temperatures of 58° and 75° C., and determining their content of moisture and total and noncoagulable nitrogen. The juices were extracted in a small press devised at the station. This apparatus was given the name pressometer and the juices pressed out from the meat were called the press fluid. Approximately 11 percent more press fluid was found in the muscle heated to 58° than in that heated to 75°; moreover, the press fluid at the lower temperature contained less water and more coagulable nitrogen than that at the higher temperature. The amount of noncoagulable nitrogen was about the same at both temperatures. Translated into quality differences between rare and well-done meat, the former is shown to have more and richer juice than the latter.

(See also pp. 107, 108.)

Cooking quality of beans.—Recently completed studies by the Nebraska Station on the cooking quality of Great Northern and navy beans have led to the conclusion that the unlike cooking qualities of different varieties are due almost entirely to the physical and chemical characteristics of the seed coats. These contain relatively large amounts of pectin compounds, relatively small amounts of protein, and large but varying amounts of calcium. The Great Northern

variety is almost twice as rich as the navy variety in calcium, the element largely responsible for hardness in water. In the 1935 report it was noted that the New Mexico Station experienced difficulty in cooking pinto beans in hard water. The Nebraska studies show the same difficulty when the calcium is in excess in the seed coat. Attempts to soften the coats by using different salts and acids were successful with ammonium salts of organic acids, such as ammonium carbonate, and with sodium bicarbonate or baking soda, a substance commonly added to the water in cooking any kind of beans. A new suggestion for softening the beans is to store them in sealed jars, for the Nebraska workers found that while the beans hardened when stored uncovered at ordinary temperature, they actually improved in cooking quality when stored in sealed jars at relatively high temperatures, 72° to 80° F., or in some cases at temperatures as low as 45°.

Cooking quality of potatoes.—What factors are responsible for good or poor cooking quality in potatoes, and what methods are best for judging cooking quality, are questions that continue to receive considerable attention at the experiment stations in States where potatoes are an important agricultural crop. In addition to progress reports from several of the stations, publications from two of the stations have appeared during the year summarizing the work of several years. A contribution from the Pennsylvania Station to the American Potato Journal covers experimental work from 1929 to 1933 on the effect of numerous factors on the culinary quality of potatoes. The station concludes that external tuber characteristics are not a reliable index of quality except that small poorly shaped or immature potatoes, as would be expected, are of poor quality. The evidence from cooking and chemical tests points to a close relationship of high starch and dry matter, and low protein content with poor quality. The fact that baked potatoes with moisture losses amounting to about 25 percent gave higher quality scores than boiled ones of the same lot, with no loss in moisture, is thought to substantiate the theory that a higher proportion of starch to water within the tuber gives a better quality. Of other factors which influence quality the station found temperature of storage and variety to be the most important.

The Maine Station has rendered a good service to potato producers and consumers in including with the report of investigations at the station covering about 7 years a critical review of the extensive literature on this subject, a large proportion of which represents contributions from various experiment stations. Some idea of the extent and scope of work which has been done on the potato may be seen from the fact that this report, station Bulletin 383, Factors Affecting the Cooking Quality of Potatoes, is 377 pages in length, with 10 additional pages of literature citations.

The work at the Maine Station suggests a certain correlation between the percentage of starch or dry matter and mealiness, but with many exceptions to the general rule. The negative correlation between nitrogen content and mealiness is considered to be too irregular to have much significance. In the absence of satisfactory chemical or physical standards for cooking quality, the station recommends buying potatoes by sample and testing the sample under the cooking conditions to be employed in the household as—

the most certain method by which the consumer can insure his satisfaction. Storage at temperatures as high as 50° F. is essential to retain or improve quality found at time of purchase. Inspection at the market may enable one to avoid lots which will give excessive paring waste, but neither appearance nor variety can insure uniform cooking qualities.

Other useful hints to the housewife are given as follows:

Cooking technics influence mealiness, relatively high temperatures and practices which facilitate escape of steam after cooking is complete being favorable. Probably baking and boiling are superior to steaming for highest mealiness. * * * Sloughing can be minimized by cooking bud and stem halves of tubers separately, especially in the fall when bud ends cook more quickly than stem ends. * * * Browning, especially noticeable when frying is the method of cooking, is due to caramelization of sugar and can be controlled indirectly through storage temperatures.

Other types of color change on cooking potatoes are noted. One of these is caused by the action of iron salts or certain types of hard water on pigment-producing material in the potato. The blackening which may develop on cooking, and especially on standing after cooking, is attributed to an amino acid or other compound which oxidizes to form pigments of the melanin type. Of more interest to the housewife than the explanation of the cause of this color change are methods given for its prevention "by soaking pared tubers 2½ hours before cooking, by cooking in acidified water, or by cooking in milk or adding milk immediately after mashing." A clue as to why some potatoes blacken and others do not has been obtained by the Wisconsin Station in the discovery of a correlation between discoloration in several varieties of potatoes and lack of potassium in the soil in which they were grown. While a liberal supply of potash does not always prevent this discoloration, this fertilizer constituent is thought to be a sufficiently significant factor to warrant guarding against a deficiency of potash in the soil used for growing potatoes.

Lard as a shortening agent.—As has been noted in previous reports, attempts are being made by various stations to find new uses for lard as well as to improve its quality. The use of lard in cake making is receiving special attention at several of the stations. In a survey of consumer preferences for different types of shortening agents for cakes among 1,600 Nebraska housewives, the Nebraska Station found that 50 percent of the women used butter, 25 percent cream, and 20 percent lard, while 65 percent preferred butter, 18 percent cream, and only 3 percent lard. Flavor, texture, and availability were the most frequently expressed reasons for using one type of shortening agent or another, with nutritive value, creaming qualities, and cost of minor consideration.

Attempts of the Nebraska Station to make a satisfactory cake by standard conventional methods, using lard as the shortening agent, were unsuccessful, but with certain modifications satisfactory products were obtained. This was also the experience of the North Dakota Station where all of the facilities of the cereal chemistry baking laboratories were used to control the various manipulations. The standard method and formula used by the cereal chemists in testing cake flour gave good results when hydrogenated fats were used as a shortening agent, but with lard the batter was of low viscosity and off color, and the cakes had low volume, poor texture and crumb, shiny crust, and a marked odor and flavor. After a

series of modifications of the standard method a formula was developed which gave a cake comparable in volume and quality with the standard. The station suggests the following simple changes in adapting ordinary cake-making recipes and methods to the use of lard as a shortening agent: Increase the amount of shortening and decrease the amount of liquid and sugar. Do not mix all ingredients dry but reserve part of the sugar to use with the egg white as a meringue. Use a lower oven temperature to get proper color and texture of crust.

To determine the cause of differences in the shortening value of various lards and other fats, extensive studies are being conducted at Iowa State College on the relation of physical and chemical characteristics of shortening agents to their value in pastries and cake and their use as frying agents for doughnuts. As a pastry test, the breaking strengths of standard wafers were determined with a device known as a shortometer. The values varied with the different fats from a minimum of 5.7 ounces for a drip-rendered lard, to a maximum of 15.49 for butter. In addition to the pastry tests, the fats were also used in an eggless cooky formula. Although the order of breaking strengths was not exactly the same as in the pastry tests, again the lard gave the lowest and butter the highest breaking strength. However, the differences were not great, for the breaking strength of the cookies made with drip-rendered lard was 13.72 ounces and with butter 16.78. These results show that of the shortening agents tested, lard was the best and butter the poorest for pastry and that the type of the shortening agent did not appear to be as important in certain types of cookies as in pastry.

Among the fats tested in the Iowa study were hydrogenated cottonseed oil and hydrogenated lard. These gave almost identical breaking-strength values, 8.85 and 8.89 ounces, respectively, in the pastry-wafer tests, and 15.27 and 15.22 in the eggless cooky tests. These values are between those reported for lard and butter.

The Indiana Station has compared the shortening properties of lard prepared under known conditions with the same lard after hydrogenation as in commercial practice. The lard used was an open kettle-rendered product produced from all the leaf fat and one fat back of each of 20 hogs fed on a known soybean-corn-mineral ration at the station. The flavor of pastry made with the hydrogenated lard was rated as more desirable than that from the untreated lard. However, the breaking strength of the wafers in pastry tests was higher, indicating a less tender product, although as tender as similar wafers made with a commercial hydrogenated fat.

Starch cookery.—One of the most baffling problems in the baking industry is that of staling. What changes take place during the staling of bread or cake and how may they be avoided and the period of freshness prolonged? Highly technical research on starches at the Illinois Station gives promise of throwing some light on this question. The Illinois investigators prepared 5-percent gels at temperatures of from 70° to 95° C. from corn and wheat starches by methods developed in their earlier work, froze these gels at temperatures just below freezing, and also at the much lower temperature of solid carbon dioxide, and then let the gels thaw at room temperature. On thawing, both cornstarch and wheat-starch gels frozen at −2° to

−3° became very fibrous and spongy, in that water could be taken up and squeezed out repeatedly, while those frozen at the very low temperature acted much like the original gels. These differences were even more marked in the appearance of the starch grain structure on microscopic examination.

The connection between this work and the staling of bread may seem remote, but it is known that bread grows stale rapidly at temperatures around the freezing point and retains its freshness remarkably at much lower temperatures. In fact, low-temperature frozen storage has been recommended to bakers as a practical means of keeping bread fresh. It is also known that moisture in any food product freezes in minute crystals at a very low temperature in contrast with large crystals on ordinary freezing. The prevention of staling of bread in intense cold must therefore be due in part to the formation of such small ice crystals that there is no dehydration or drying of the starch, while in the slow freezing around 0° C. the production of large ice crystals tends to dehydrate the starch. Perhaps in time the housewife in districts where frozen-storage space at very low temperatures is available may find it a saving in time to bake bread in large batches and store it until needed along with the frozen meat, fruits, and vegetables.

FOOD PRESERVATION

At several of the experiment stations, problems of food preservation and utilization are receiving much attention. Progress in this field is of interest to consumers as well as to producers, because they benefit by improved quality in food products on the market, and welcome the variety afforded by new products. The farm housewife welcomes suggestions for new methods of utilizing farm products and can often get ideas for the home preservation of foods from methods developed for large-scale use. The spoilage of processed foods, both manufactured and home produced, also receives attention as an essential part of the research program on food preservation.

Cranberry juice.—Bottled cranberry juice is now one of the popular fruit juices on the market, largely as a result of continued research at the Massachusetts Station. A recent improvement in the method of manufacture devised by the station has been the use of a pectinous enzyme preparation in the clarification of both raw-pressed and hot-pressed cranberry juice. The yield of raw-pressed juice is from 2.5 to 3 gallons per barrel (100 pounds) of the cranberries.

Grape juice.—The results obtained in chemical and bacteriological research at the New York State Station on the manufacture of grape juice have been used by the station in the preparation of Circular 166, Making Grape Juice in the Home. Included in this circular are directions for the pressing and preliminary heating or pasteurization of the juice, its temporary storage in large containers to permit the crystallization and settling out of sediment (a step not always taken in the home preparation of the juice), and the second pasteurization and bottling. The circular emphasizes the importance of filling the bottles hot to drive out air from the juice and from the head space of the bottle, a precaution necessary to prevent later deterioration of the juice. Two forms of hand presses are illustrated;

one, a small-type screw press, and the other, a simple wooden press of the nutcracker type easily made at home. (See also p. 70.)

Rhubarb juice.—The New York State Station has also developed a method for preparing rhubarb juice. The method as described is better suited as yet to commercial manufacture than home preparation because it is rather elaborate, involving pressing the juice from the shredded stalk with a hydraulic press, heating it to 120° F., and clarifying it with a pectic enzyme preparation. A further step in the process consists in precipitating out the soluble oxalates in the juice (which may be harmful) by heating with calcium carbonate to 180° C. and then chilling it to from 32° to 40°. The resulting juice is said to be brilliantly clear and to remain in this condition and retain its characteristic rhubarb flavor during nearly a year's storage. Suggested uses for the juice are as a plain or carbonated beverage after dilution and sweetening, and as a blender with other fruit juices such as sweet or insipid cider, Montmorency cherry juice, Concord grape juice, and citrus and berry juices. With the demand for rhubarb largely seasonal, juice preparation during the off season should be profitable. Among the varieties tested the Strawberry gave a particularly rich flavor, and the Ruby a redder and more attractive juice.

Strawberry juice.—A method applicable to home use has been developed by the Tennessee Station for making strawberry juice or semisirup. The directions call for moderate heating of the sirup to 190° F. and holding at approximately this temperature for about 15 minutes, after which the juice is squeezed or pressed through muslin and sweetened by adding sugar at the rate of 2 pounds to 1 quart of juice. The warm semisirup is finally poured into sterile bottles, which are capped and held for 30 minutes submerged in water heated to 175°. The Blakemore variety was found to give the richest flavor and best color of any of the varieties thus far tested by the station. Suggested uses for the juice, which as thus prepared is said to be about one-half as rich in vitamin C as fresh strawberries, are as a sauce on ice cream, for blending in fruit punches, and for other flavoring purposes.

Orange juice.—The distribution of fresh orange juice to homes along with the milk has been attempted in many places without marked success because of deterioration in the flavor of the juice on standing for any length of time. Several years ago the Florida Station began an intensive study of the problem and has now developed processes of extraction and handling of the juice on a commercial scale that are said to assure a product free from the objectionable features of the juice as manufactured earlier. It is stated that—

> when the system devised in the experiment station laboratories is followed, fresh orange juice may be produced, in specially equipped cold storage plants, without sterilization, that is of excellent and uniform quality. Distribution can be made in ordinary milk bottles, with full assurance that the juice will retain all the desirable attributes for at least 4 days.

Meantime, bottled orange beverages prepared by reconstituting an orange-juice concentrate with water are likely to be confused with undiluted orange juice. As these beverages seldom contain more than 10 to 15 percent of orange juice, with perhaps a small amount

of lemon juice to standardize the acidity, they are not a satisfactory substitute for orange juice as a source of vitamin C. This has been proved experimentally by the Massachusetts Station which reports that the very best of this type of beverage contained less than one-fourth as much vitamin C as fresh or canned orange juice and most of them contained only negligible amounts.

Sweetening sirups.—A year or two ago the Tennessee Station developed a method of making a palatable sweetening sirup from sweetpotatoes. The North Dakota Station has now found that the small buttercup squash developed by the station can be used to make a palatable sirup of distinct flavor, lighter in color than molasses and resembling sorgo sirup.

One of the difficulties encountered in making sorgo sirup is the cloudiness that often develops on standing. The Tennessee Station has found that this can be prevented by adding the proper amount of the enzyme invertase, now commercially available as a standardized product, to the juice after evaporation to the semisirup stage and cooling to about 140° F. The juice is allowed to stand for 12 hours after the invertase has been added, and the evaporation is then continued to the required concentration. Sirup prepared by this method has remained clear and free from sugar crystals after standing for 6 months.

A novel sweetening sirup has been prepared by the Florida Station by blending citrus juices with cane juice before the latter is evaporated to sirup in the usual way. Preliminary tests have shown that the proportion of citrus juice to cane juice should not exceed 1 to 7. The inclusion of either grapefruit juice or orange juice even in much smaller proportions than 1 to 7 is said to be effective in preventing crystallization of the sugar on standing. The blended sirup is considered to be superior in flavor to pure cane sirup.

Corn sugar in pickles and preserves.—Purified, crystalline corn sugar (dextrose) is recommended by the Massachusetts Station as a partial substitute for cane sugar (sucrose) for many jams, jellies, preserves, canned and frozen fruits, and pickles. For most products it should replace not more than one-fourth of the sugar because of crystal formation, insufficient sweetness, or a changed flavor with larger proportions. However, sweet pickles are improved in texture and appearance when at least half of the total sugar is corn sugar. In making cucumber, pepper, or green-tomato pickles, corn sugar hastens fermentation and increases the production of acids, both of which are desirable. Corn sugar should not be used in canning sweet corn or peas, as it produces a marked darkening in these nonacid products.

Bacterial spoilage of processed foods.—The stations are often called upon to determine the cause of spoilage in canned and manufactured food products, or to trace outbreaks of food infection. In certain types of products it may be necessary to discover at what point in the manufacturing process contamination occurred. The Michigan Station recently investigated the cause of spoilage of frankfurters through the formation of slime and mold. The method followed illustrates the way in which the organisms causing bacterial spoilage are traced through the different stages of the manufacturing process. In this particular instance it was found that the frank

furters taken directly from the cooker had an average of 4.5, those taken from the cooling spray 3.5, from the drier 3,332, and from cold storage 22,400 bacteria per link. It was found that the air used for drying was drawn from a passageway with a dirty floor and that used for the circulating system in the cold-storage room was drawn from the outside without any attempt to purify it. Samples of air from both places showed high bacterial counts and indicated beyond doubt that the air in the plant was the source of contamination, resulting in the spoilage of the product after removal from cold storage to warmer temperatures.

FOOD VALUES

Knowledge of the composition of foods is essential in planning special diets and in checking menus and food-consumption data for adequacy. Complete information on any food includes (1) its proximate composition, that is, its content of protein, carbohydrate, fat, and water; (2) its content of minerals, particularly calcium, phosphorus, and iron, and sometimes iodine, copper, and manganese; and (3) its content of the various vitamins as far as they are known. In this section a few examples will be given of recent experiment station contributions to knowledge of food composition along these three lines. Further reference to vitamin C content of foods and to certain trace elements will be found in other sections. (See also pp. 103, 138.)

Nutritive value of tropical and subtropical fruits.—In response to many inquiries received by the home economics department of the University of Hawaii and the nutrition laboratory of the Hawaii Experiment Station regarding the use and nutritive value of local fruits, Bulletin 77, Some Fruits of Hawaii, has been published by the station to supply the desired information on 25 widely used Hawaiian fruits. For each of these fruits the general information given includes description (in some cases with photograph), history, special nutritive value, supply, and selected recipes. Tabulated data are reported on the proximate composition and total ash, calcium, phosphorus, and iron content of practically all of the fruits, and for a small number quantitative vitamin values. With the introduction of more and more tropical and semitropical fruits in this country and their availability on the market, this publication should be useful in the States as well as Hawaii. A few of the fruits described are avocado, breadfruit, guava, mango, papaya, passion fruit, poha, and tamarind. The Florida Station also has reported chemical analyses of tropical and subtropical fruits, stating that—

> there are more than 600 edible fruits found in the tropics and subtropics, and of these less than 50 are in general cultivation, with not more than 20 being sold commercially. Of these 20, only a very few are known to the entire population of the country.

The mineral content of sirups, molasses, and soft sugars.—It used to be thought that sirups and sugars were valuable only for their high energy content. Now some of these products, particularly those prepared in a rather crude way on the farm, are valued as inexpensive sources of minerals, particularly iron and copper. The Mississippi Station, in connection with studies on nutritional anemia, has analyzed many samples of sirup, particularly sorgo and sugarcane

sirups made on the farms in the State, and a wide variety of commercial sirups, molasses, and sugars. The accumulated data show great variation in the mineral content of the different types of sirups and sugars. In general, sorgo sirups may be said to have a high iron and copper content. Sugarcane sirup, especially when concentrated by boiling on an iron pan as is the custom on the farm, may be an excellent source of iron. Both sorgo and sugarcane sirup contain fair amounts of copper and phosphorus. The blends of corn and refiners' sirup may be good sources of iron and copper, depending on the nature of the refiners' sirup used. Molasses has a high content, particularly iron and calcium, but as its mineral content increases its palatability decreases. Brown sugar may contain appreciable quantities of mineral, especially iron and copper, these decreasing with increased purification and lighter color of the sugar.

Iodine in foods.—The discovery several years ago that iodine is an essential constituent of foods and that in regions where the iodine content of locally grown foods is very low, endemic goiter occurs, has led to a widespread interest in the natural iodine content of plant and animal foods in various sections of the country, the cause of the wide differences found, and means of increasing the iodine in natural foods.

Following an examination of typical samples of commonly grown vegetables, the Oklahoma Station reported that vegetables grown in the State compare favorably with those of other regions in iodine content and that the iodine content is influenced more by the place of growth than the variety.

It is especially noticeable that where salty waters are used in irrigation, or where these waters normally occur, the iodine content of the vegetables produced is often doubled. Iodine is more plentiful in those parts of the plant where the green coloring matter is most intense. It has been observed that the young green leaves always contain more than the etiolated leaves; that there is more in the leaves than in the stem, and the least amount is present in the storage roots. However, if the stem is green and rapidly growing, as the asparagus, it may be an excellent source. Likewise the pod of the okra has proved to be very rich in iodine in the samples analyzed.

The iodine content of certain vegetables grown with and without the addition of potassium iodide to the soil was determined by the Kentucky Station. Two samples of potatoes grown on iodized soil contained five times as much iodine as those grown on soil that was not treated. They were also free from scab while the potatoes grown on untreated soils were not. The iodine content of corn grown on treated soil was also several times higher than that of corn grown on untreated soils. Some vegetables were found by the Pennsylvania Station to be much more efficient than others in taking up iodine from the soil. The turnip proved to be particularly efficient in this respect, for samples grown on soils liberally supplied with available iodine were more than 100 times as rich in iodine as when grown on untreated soils.

The water supply for the growing crops is considered by the Georgia Station to be one of the factors having a marked influence on the iodine content of vegetable crops. Analyses of turnip tops and mustard greens grown on soils with low, medium, and high water supply showed increasing amounts of iodine with increase in the water supply. The capacity of turnips to take up iodine was also

shown in the data reported by the Georgia Station, for the increase in iodine content of turnips following iodine treatment of the soil was much greater than that of potatoes. The turnip tops and mustard greens had a very much higher natural content of iodine than the potatoes, thus confirming the Oklahoma findings that green leafy vegetables are much richer in iodine than are roots or storage organs.

It has been found possible to increase the iodine content of some foods of animal origin as well as vegetable by the administration of iodine in suitable form. The New York (Cornell) Station increased the iodine content of hens' eggs until they were richer in iodine than lobster, and the iodine content of cows' milk to that found in sea fish and salt-water shellfish. The method followed in increasing the iodine content of milk is to add small amounts of dried marine vegetation such as kelp to the grain rations of the milch cows. Milk thus produced has been used for several years with successful results in goiter control.

Vitamin A in squashes.—The common deep-yellow-flesh Hubbard squash has been found by the Arizona Station to be very rich in vitamin A, containing 5,000 Sherman units per 100 grams. This is practically the same amount as has been found in mature carrots, yellow sweetpotatoes, and fresh apricots, all of which also have a deep yellow color. The Zuccini or Italian squash with a dark-green edible skin contained 500 units of vitamin A per 100 grams, or only one-tenth as much as the Hubbard squash, and about as much as has been reported for avocado, green asparagus, and cantaloup. The small fluted light-green summer squash contained even less vitamin A, only 300 units per 100 grams, or about as much as brussels sprouts, artichokes, bananas, and whole milk. The Hubbard squash was fed raw, and the other two varieties cooked; however, vitamin A is not easily destroyed by ordinary cooking processes.

Vitamins A, B, and C in Hawaiian fruits.—Quantitative vitamin A values for tropical and subtropical fruits given in the Hawaii bulletin noted on page 10 are: Whole figs 80, guava with seeds removed 200, papaya 2,500, pineapple pulp 100, and pohas 4,000 International units per 100 grams. The poha, which had the highest vitamin A content of any of the fruits tested, is described as a small yellow-green or orange fruit, another example of association of vitamin A with yellow color. Vitamin B_1 values reported in the same bulletin are: Whole figs 10, guava with seeds removed 14, papaya 8, pineapple pulp 25, pohas 50, and tamarind 100 International units per 100 grams. Of these fruits only the tamarind is considered an excellent, and the poha a good source of vitamin B_1. In the vitamin C tests on the Hawaiian fruits, orange juice was given a value of 60 Sherman units per 100 grams. Other values reported were: Figs 5, pineapple juice 20, passion fruit juice 50, and papaya 70 units. Fresh guava was given a value of 300 units, guava juice (a water extract of guava) 100, and guava jelly 60 units per 100 grams, or as much as orange juice.

Vitamin B (B_1) in meats.—Vitamin B_1 values have been reported by the Wisconsin Station for various animal tissues in the raw dried form. Pork muscle had the highest value, 666 International units per 100 grams, followed by beef and pork kidney 400, beef heart 260, pork heart 250, pork liver 130, and beef and mutton muscle 50 units

per 100 grams. Of particular interest is the very high content of vitamin B_1 in pork, which ranks almost with yeast as a source of this vitamin. The North Dakota Station likewise found dried pork muscle to be a very good source of vitamin B_1. In terms of Chase-Sherman units dried raw lean pork was reported to contain about 24 units, and dried raw lean beef 2.5 units of vitamin B_1 per gram. Although these values are given in different units from those reported by the Wisconsin Station, the relative values of pork and beef muscle are in about the same proportion. As meat is always consumed cooked or canned, the North Dakota Station made a special study of the loss of vitamin B_1 during these processes. When the ground meat was heated in a double boiler with constant stirring to 90° C. and then dried and ground again, lean pork was found to lose about 12 percent and beef about 20 percent of its original potency. When the meat was similarly heated in a pressure cooker for 7 minutes at 10 pounds pressure, the pork lost approximately 21 percent and the beef practically all of its vitamin B_1. The Wisconsin Station reported increased destruction of vitamin B_1 in pork muscle with increased time in canning under pressure, the losses ranging from 52 percent on heating at 240° F. for 1 hour to 80 percent on heating at 250° for 1 hour and 50 minutes.

FACTORS AFFECTING VITAMIN C VALUES

The development of a comparatively simple and rapid test for vitamin C that can be used with many materials in place of the time-consuming guinea pig feeding tests makes it now possible to trace in a short time the effect of many factors on the vitamin C content of foods. As noted in the 1935 report, this type of study is receiving attention at several of the stations. In most cases animal feeding tests are still used to some extent as a check on the chemical tests. The results noted below have been obtained by one or the other, or both, types of tests. Because some general conclusions can be drawn as to the effect of various factors on the stability of vitamin C, this work will be reported by factors rather than foods, but anyone particularly interested in the foods discussed will be able to get some idea of their value as sources of vitamin C. This vitamin is now universally recognized as essential not only to prevent scurvy but also to keep the various tissues of the body in a healthy condition. Many a vague symptom of ill-health is now considered to be a sign of latent or hidden scurvy; consequently it is important to know how to make the best selection of foods for vitamin C content and how to prevent losses in their preparation for the table.

Varietal differences.—It was noted in the 1934 report that different varieties of apples are not alike in their content of vitamin C. The earlier work reported was done at the Massachusetts Station, but similar results have since been obtained by the Washington Station with a few locally grown varieties. The number of fresh apples of the varieties tested required daily to protect a man from scurvy is estimated to be about two of the Winesap variety, three of the Golden Delicious, five of the Delicious and Richared, and six of the Jonathan variety. With one variety three times as rich in vitamin

C as another, the old saying "an apple a day keeps the doctor away" needs some modification.

The Maine Station has also shown a wide variation in the vitamin C content of different varieties of apples, and a similar variation in the vitamin C content of the leaves. The Northern Spy variety, for example, has a high content, and the McIntosh a low content of vitamin C in both leaves and fruit. It is suggested this may hold true for other fruits and vegetables, and that a leaf or other non-fruit test for vitamin C may possibly serve as a "vitamin sieve" to growers in the selection of varieties for their vitamin C content.

A vegetable recently tested rather extensively at both the New York State and Massachusetts Stations for factors affecting vitamin C content is the green or English pea. Analyses at the New York State Station of a large number of garden, market, and canning varieties grown at the station showed that the small-seeded varieties such as the Alaska were much richer in vitamin C than the larger-seeded varieties generally grown in home and market gardens. An exception was the Mammoth Melting Sugar pea, an edible-pod variety which proved to be higher in vitamin C than any other variety examined. In this case the pods were as rich as the peas. It would be interesting to know whether the pods of other varieties vary in vitamin C content in the same degree as the seeds, as was the case of the leaves and fruit of the apple in the Maine study. Certain varieties of tomatoes, snap beans, and spinach were also found by the New York State Station to be much richer in vitamin C than others. For example, the early Detroit and Golden Queen tomatoes were 50 percent more potent than the other varieties tested. Georgian and Blue Lake snap beans contained approximately one-half the amount of vitamin C found in the Tendergreen, Kidney Wax, Ideal Market, and Kentucky Wonder varieties. The Princess Juliana and King of Denmark varieties of spinach contained less vitamin C than 10 other varieties grown at the station.

Perhaps the marked differences that have been found by the Massachusetts Station in the vitamin C content of different commercial brands of tomato juice may be due quite as much to the variety of tomatoes grown for canning as to the methods employed in the different canneries. At any rate one of the points that might well be given attention by the canning industry, regarding any food the vitamin C content of which is a sales point, is the selection of varieties known to be especially rich in vitamin C. This holds equally well for frozen storage or any other method of food preservation. With frozen berries quite an industry in the Pacific Northwest, it is of interest that studies at the Washington Station have shown that frozen raspberries of the Lloyd George variety contained considerably more vitamin C than those of the Cuthbert red raspberries, the proportion being as 5 to 3. On the other hand, several varieties of frozen blueberries were found by the Massachusetts Station to differ little in vitamin C content.

These illustrations show that variety may or may not play an important part in judging the value of any fruit or vegetable for its vitamin C content, and suggest that more attention should be paid than in the past to the testing and selection of varieties for vitamin C value. However, this is not the only factor to be con-

sidered. Season, soil conditions, maturity, and many other factors may also have an influence on the vitamin C content of the original food material.

Common storage.—Both the Washington Station studies with apples and the New York State Station studies with peas and other vegetables included the effect of storage on vitamin C content. As noted in an earlier report, the Washington Station considers that losses of vitamin C in apples on storage begin at temperatures just above freezing and increase at higher temperatures and on prolonged storage. At 45° F. or common storage temperature the Delicious or Richared apples, which showed no loss of vitamin C at 32°, lost about one-sixth of their vitamin C value in 3 months, one-fourth after 6 months, and one-half after 12 months. Green peas were found by the New York State Station to lose their vitamin C very rapidly if held at room temperature or higher for any length of time after picking. Refrigeration checked this loss. The Massachusetts Station also found that shipment of peas without refrigeration, or storage in the pod for 1 or more days, had a marked destructive effect on the vitamin C content. In shipping peas it is the custom to use refrigeration of some sort, but delay between the time of picking and refrigeration may make the latter of little value from the standpoint of protection against losses of vitamin C. Prompt cooling after harvesting is emphasized by the New York State Station as a necessity if the full nutritive value of the peas is to be retained. Peas from the home garden should receive the same attention or else be picked just before they are to be cooked. It is safe to apply this rule to most seasonal vegetables. The acidity of tomatoes and small fruits affords some protection to their vitamin C content.

Preliminary reports on a long-continued investigation at the Wyoming Station of the effect of storage on the vitamin C content of Wyoming potatoes were noted in the 1934 report. It was stated that the loss of vitamin C in stored potatoes during the winter is such that it is not safe to depend upon them in the spring for vitamin C protection. This would probably apply also to other so-called winter vegetables. The complete report of the Wyoming investigation shows that approximately one-half of the vitamin C content of the potato is lost during 6 months' storage in a storage cellar ranging in temperature from 38° to 42° F.

Frozen storage.—Probably the freezing process in itself has a protective rather than a destructive effect on vitamin C, but the preliminary blanching of vegetables and the defrosting which takes place either accidentally in products which should be cooked without defrosting or purposely in such products as are eaten raw may have a destructive effect. The New York State Station found that the blanching process customarily used for peas preliminary to freezing resulted in a vitamin C loss of from 10 to 30 percent, depending on the method followed, and the Massachusetts Station noted that peas defrosted for several hours retained only about 30 percent of the amount found present in the frozen product. Frozen-pack laboratories are working out improved methods of freezing to retain as much as possible of the original vitamin C content of the food. With frozen storage rapidly coming into use as a means of preserving farm

products for consumption in the home, it is well to remember that long defrosting may undo the beneficial effects of the freezing process as regards unstable vitamins.

Testing different methods of preserving vegetables, the Massachusetts Station found that freezing caused practically no loss in nutritive value and palatability, but that in cooking some of the vitamins (B and C) may be destroyed by the heat and dissolved in the liquids. It was noted also that certain soluble constituents, such as proteins, carbohydrates, and minerals, may be lost in the cooking water. Drying of vegetables caused some loss of the vitamins, and pickling decreased many of the nutritive properties. In the preparation of sauerkraut, cabbage lost some proteins, minerals, and part of its vitamin C.

(See also p. 69.)

Cooking and canning.—It is an old story that there is likelihood of considerable loss of vitamin C in various cooking processes, either through actual destruction or the passage of the vitamin from the food into the water where it is lost unless the cooking water is used. The New York State Station is of the opinion that, contrary to the general belief, but little of the vitamin C content of vegetables is actually destroyed during cooking. In a study of the losses of vitamin C during the cooking of peas to an arbitrary stage of doneness, it was found that the greatest destruction occurred during the first 2 minutes of cooking, or the time it took the water to return to the boiling point after the peas had been placed in the boiling water. The rate of destruction thereafter was very small, showing that a few minutes of overcooking or undercooking is not an important factor. In peas of the Thomas Laxton variety cooked to the "done" stage, the total loss of vitamin C was 10 percent, while the remaining 90 percent was divided between the peas and cooking water in the proportion of 42 to 48 percent. In Alderman peas, the total destruction was 5 percent, with 53 percent retained in the peas and 40 percent in the cooking water.

The waste of vitamin C in discarding the water in which peas, and presumably other small vegetables, are cooked may be seen from the fact that in the tests reported the cooking water from the peas contained from 0.10 to 0.12 milligram of vitamin C per cubic centimeter. Commenting on these findings the station gives this advice to the housewife: "It is evident that methods of cooking should be adopted which will make use of this nutritionally valuable substance which is too often discarded." A recent item from the Massachusetts Station states that the vitamin C content of fresh lima beans was reduced about 60 percent on cooking. The report does not state whether or not the cooking water was also tested.

With fruits and berries there is either no addition of water on cooking and canning or, if water is added, the juice is customarily not discarded, so that it is a question of destruction rather than avoidable loss. Rhubarb, when tested in the raw state, was found by the Massachusetts Station to be a good source of vitamin C, as can be seen by the fact that the protective level for guinea pigs was from 3 to 4.5 grams daily in comparison with the usual value for orange juice of 1.5 to 2 grams. Cooking the rhubarb in a sauce, however, caused a loss of 30 or 40 percent of the vitamin, and canning in water so great a loss that 7 grams daily of the canned material, equivalent

to 5.3 grams of the original rhubarb, did not protect guinea pigs against scurvy. The Washington Station has reported that Jonathan apples lost about half of their vitamin C when made into apple sauce. Many fruits, however, retain their vitamin C to a marked degree on cooking and canning.

Probably the most inexpensive and valuable home-canned product for vitamin C is canned tomatoes or tomato juice. Further studies at the Wisconsin Station on methods of retaining vitamin C in tomato juice most effectively have led to the following directions:

(1) Steam the tomatoes with the skins on for 10 minutes, (2) sieve immediately without first removing the skins, (3) either pour the juice into containers while it is still hot or reheat it to 176° F. and then pour at once into containers, (4) seal immediately, (5) process in a water bath for 45 minutes at 212° F. (boiling).

TRACE ELEMENTS IN NUTRITION

The experiment stations have made important discoveries concerning the function of essential trace elements, such as iron, copper, zinc, and manganese, and the harmful effects of other trace elements, such as selenium and fluorine, and are continuing to devote much attention to various problems concerning the significance of these elements in plant nutrition (p. 20), animal nutrition (pp. 93, 94, 95, 97), and human nutrition. Recent work on iron and copper as essential, and fluorine as harmful to numan nutrition will be noted briefly.

Iron and copper deficiency in relation to anemia.—Wide variations have been noted by the Florida Station in the total iron content of foods grown on the poorer and better types of soil in the State. The iron content of turnip tops varied from 90 parts per million on very poor soil to 318 parts on rich soil. A similar wide variation has been found in the extent of simple nutritional anemia (low hemoglobin content of the blood) among children living in these different soil areas. In certain school districts the proportion of children with anemia was as low as 3 percent, and in others on poorer soil as high as 80 to 96 percent. This shows that in localities where the iron content of the soil is very low dependence should not be placed on home-grown foods as a source of iron.

Goats' milk is sometimes said to cause anemia in infants. It was formerly thought the anemia was of a different type from the nutritional anemia due to lack of iron and copper induced by exclusive feeding on cows' milk. Experiments at the Wisconsin Station have shown that goats' milk is low in iron and perhaps copper, for rats made anemic by drinking only goats' milk were readily cured by iron and copper salts. This means that the same precaution should be taken as with cows' milk to prevent anemia in infants subsisting on goats' milk—iron medication or the inclusion in the diet of foods with high available iron, such as egg yolk.

The rather widespread use of bananas and milk as a reducing diet led the Arizona Station to question whether this might not lead to a serious iron deficiency. In view of the distinction now made between total iron and available iron, the Arizona investigators studied the availability of the iron in the banana, both biologically and chemically. The banana is so low in total iron that not enough could be fed the anemic rats in the biological tests even when banana powder was used instead of fresh bananas to furnish the amount of iron

used in standard tests. However, by feeding some animals as much of the banana powder as they would eat, and others as much inorganic iron as was contained in the amount of banana eaten, with and without supplements of copper, it was demonstrated that the iron in the banana is from 90 to 100 percent available, and that copper is the limiting factor in the banana for complete utilization of the iron. This study is of particular interest in demonstrating that the availability of iron can be determined biologically even with food materials very low in iron. Chemical tests checked with the biological in showing almost complete availability of the iron.

The discovery that some forms of iron are much more available to the body than others has raised the question of possible differences in the availability of copper from various sources. A study of this question at the Wisconsin Station has led to the conclusion that copper in most foodstuffs is probably almost entirely in available form. The same amount of copper as present in pork heart muscle, wheat germ, alfalfa, and yeast was as effective when combined with an adequate amount of iron as equivalent amounts of copper in the form of copper sulphate. Various other copper salts also proved as effective as copper sulphate. Preliminary tests have indicated that when iron and copper are both supplied in the form of pyrophosphate in amounts of 0.5 and 0.01 milligrams, respectively, satisfactory hemoglobin regeneration takes place. Although all of these studies have been with experimental rats, direct application of the results to infant feeding is being continued by the Wisconsin Station in cooperation with the university hospital and welfare clinics, with ample evidence that many anemic infants respond more readily to iron and copper combined than to iron alone.

Rats are also being used by the Wisconsin Station in studies on the storage of iron in the body. In a preliminary report of this investigation it is stated that the amount of iron in the young at birth has been found to depend on the amounts stored by the mother, that females accumulate larger stores of iron than males, that during pregnancy these iron stores are rapidly depleted as the amount in the fetuses increases, and that after the birth of the young the stores are rapidly increased to normal levels. In all of these experiments the rats were, of course, provided with ample iron and copper. These findings afford a good argument for a plentiful supply of iron during pregnancy.

Fluorine excess and mottled enamel.—The presence of fluorine in minute amounts in the drinking water was definitely established by the Arizona Station in 1931 as the cause of mottled enamel, the disfiguring and destructive change in the teeth which has been described in earlier reports. Since that time the station has continued to study the problem of mottled enamel from many angles. Studies of the fluorine content of the drinking water and the extent of mottled enamel among school children have been extended to cover most of the State, always with similar results. Among children living in the same district during the time in which their permanent teeth were developing, no mottling of the teeth was found in districts where the water contained less than 0.8 part of fluorine per million, a very mild degree with 0.9, mild to moderate with from 1 to 2, and severe mottling with from 3 to 6 parts of fluorine per

million of water. In districts where the water contained 6 parts or more of fluorine per million, the temporary or deciduous teeth were also affected with severe pitting and chipping. Water containing more than 8 to 10 parts per million was found to be unsafe even when used only for cooking purposes.

Analyses of the central water supplies of 11 cities in one section of the State showed the fluorine content to be below the danger level. The school children using the city water were free from mottled enamel, while others using private wells, the water of which had a high fluorine content, had mottled enamel. In 17 school districts in a nearby rural section, over one-third of the children were affected. In one district in which over half of the school children had severely mottled teeth, the drinking water was found to contain from 12 to 18 parts of fluorine per million. In general, the deep wells contained less fluorine than the more shallow wells, indicating that safe water supplies may be obtained in some instances by drilling deeper wells to get below the source of fluorine contamination. The Arizona investigators are of the opinion that no satisfactory chemical method of removing fluorine from water supplies has yet been developed. Of various means that have been suggested, removal by freezing is considered impractical, and by precipitation with aluminum sulphate or by the use of activated carbon prohibitive in cost.

Variation in the severity of mottled enamel in human subjects using the same water supply suggested the possibility that the destructive decalcifying action of fluorine might be inhibited by dietary improvement. In the early work at the Arizona Station, the possibility that dietary deficiency might be responsible for the defect was tested with negative results, except for the observation that the children with the most severe type of mottled enamel were getting much less vitamin C in their diet than others with less severe mottling. It was thought that differences in this factor and possibly others might explain the observed differences and susceptibility to the harmful effects of fluorine. However, an extensive series of experiments involving the use of approximately 1,500 animals and various combinations of diet factors has led the Arizona investigators to conclude that mottled enamel through fluorine injury cannot be prevented by any dietary improvement, and insufficient intake of any of the dietary factors investigated (which included calcium, phosphorus, vitamins C and D, proteins, and variations in the acid-base balance) does not increase the susceptibility to the destructive action of fluorine on the teeth. However, a deficiency in any of the dietary factors essential for normal tooth formation may result in teeth which are "doubly" defective.

NUTRITION AND HEALTH OF CHILDREN

Checking the weight and height of children against standards for different ages was formerly considered one of the best means of judging nutritional status, but little by little evidence has accumulated indicating that no single set of height and weight standards is applicable to all children, and that there are many factors influencing the growth rate. All authorities agree, however, that it is

advisable to watch the height and weight gains of the individual child to detect irregularities which may be of significance.

Seasonal variations in growth in weight and height.—Records of growth in weight and height of large numbers of Mexican, white, and Negro school children in San Antonio, Tex., were analyzed by the Texas Station for seasonal differences in growth rate. Three seasons were considered—spring, from February to April; summer, from May to September; and fall, from October to January, inclusive. Growth in height, both sitting and standing, was fairly uniform throughout the year. Slightly better average gains in weight were made by all three racial groups in the fall than in the other seasons, but the relative gains in the other two seasons were not consistent. The Negro group gained nearly as much in the summer as in the fall, and much less in the spring. Smaller seasonal differences were shown by the white children than the other two groups, and the gains of the Mexican children were not consistent by seasons during the 2 years of the study. October was found to be the month of outstanding gains, the average net gains for the three groups ranging from 11.3 to 16.1 percent of the yearly gains. April was the month of poorest gains, averaging only 1.4 to 6.4 percent of the yearly net gains. No explanation of these marked differences could be found in the records of food eaten, of minor illnesses, especially colds, and of climatic conditions.

When the individual rather than the group records were examined for seasonal differences, it was found that all three races had higher ratios of gains than losses in weight in the fall than in the spring. In about two-thirds of 98 children who at no time showed losses in weight, the rate of gain in the fall was greater than in the other two seasons, but in the other third the gain was greater in either the spring or summer than in the fall. These differences in the rate of growth in weight are considered by the station to emphasize—

> the importance of considering each child individually in his course of growth. A child's failure to gain should not be attributed complacently to the season of the year. Too much departure from regularity of gain calls for special attention, although the degree of uniformity to be expected in normal growth must be determined by further study.

Size of rural and urban school children in Utah.—A comparison, noted briefly in the 1935 report, of size on the basis of weight and height for age of nearly 13,000 rural and 14,000 urban Utah children between the ages of 6 and 15 years showed no significant differences in the 6-year-old groups, but increasing differences in the upper-age groups, the city children tending to be taller and heavier than the rural children. Comparisons of mean heights and weights of the different age groups with the Baldwin-Wood standards showed that the rural boys were below medium height except at 6 years of age, while the urban boys were of medium height for age except at 14 years, when the average height was 1 inch below the standard. Rural girls were of medium height except at the ages of 6, 7, 12, 13, and 14, and below medium height at the other ages. Urban girls were of medium height except at the ages of 12 and 13, when they were 1 inch above medium height. In mean weight the rural boys most nearly approached the Baldwin-Wood averages, and the rural girls conformed to them least. Inasmuch as the same racial stocks were

represented in both urban and rural populations, and in practically the same proportion, the causes of smaller size in the rural than the urban children are considered environmental rather than genetic.

An earlier study by the Utah Station of the food habits of rural children in the State had furnished information on the foods commonly eaten in the winter months. To check the adequacy of the diet, a similar combination of foods was made up weekly and fed to guinea pigs and rats. Severe scurvy was produced in the guinea pigs in from 3 to 4 weeks, indicating that the children studied might have been suffering from a latent or subacute form of scurvy, which would probably inhibit growth. Rats fed the diet maintained a slow steady growth, but at a subnormal rate, which was improved by adding various combinations of vitamins A, B, D, and G. The station is investigating further the possibility of vitamin C deficiency among children both urban and rural through the use of the capillary fragility test, which as applied to the arm roughly indicates vitamin C deficiency through the breaking of the walls of the capillaries with slight subcutaneous hemorrhages. The test is not as accurate or specific as the chemical analysis of the blood or urine for vitamin C, but is considered of considerable value in the examination of large numbers of individuals.

Nutrition of rural children in Maine.—An investigation by the Maine Station of the food habits and physical condition of rural school children is worthy of note before its completion because the methods followed illustrate the possibility of combining a research and an educational program. Three towns were selected for the study, one in the potato-growing district, another in a typical fishing district, and a third in a general-farming district. In the fall complete physical examinations of the school children were made, including various physical measurements, examination of the teeth, determination of the hemoglobin in the blood, and the capillary fragility test for vitamin C. Food records were secured during the winter, and the children were examined again in the spring.

The fall examination showed many bone and teeth defects in all three localities, wide variations in the extent of anemia as determined by the hemoglobin values, and but little evidence of vitamin C deficiency. Somewhat over 12 percent of the children were 10 percent or more under weight for height and age. The food records secured during the winter showed a general deficiency of milk, fruits, and vegetables, and an excess of white-flour products and sweets in all localities. Few children or pregnant women were receiving a regular source of vitamin D. Physical and dental examinations repeated in the spring showed a slight increase in the number of children 10 percent or more underweight, a considerable increase in the average number of tooth cavities per mouth, and a definite decrease in capillary strength, although only about 5 percent of the children had values low enough to indicate a probable deficiency of vitamin C.

In the spring an educational campaign was begun with the selection of one of the three communities for further study to determine what improvement in the nutritive state of children can be induced by such improvements in the family diets as can be secured by voluntary cooperation of the families through more extensive and better-planned home gardens and more intelligent diet planning. Health exami-

nations will be given in the fall and again in the following spring. Assisting the research workers in this project are a physician, the director of dental hygiene of the State Department of Health, a member of the county farm bureau, and a home demonstration agent.

ENERGY REQUIREMENTS OF WOMEN

In recent years basal metabolism studies, that is, studies of the energy requirement or heat production in the postabsorptive state after a night's rest, of women, have given values considerably lower than the established standards. If the standard values for basal metabolism are too high, it is possible that the predicted values for energy requirements of women at various occupations may also be too high. Studies reported during the year have contributed data both on the basal metabolism of women and the energy requirement of a particular occupational group.

Basal metabolism of young women at high altitudes.—An investigation at the Wyoming Station of the basal metabolism of 100 young women students, all of whom had lived in the State more than 10 years, is of particular interest in that the results obtained point to a higher basal metabolism of young women at high than at low altitudes, although still below the customary standards. The total calories per 24 hours in the Wyoming study ranged from 1,113 to 1,748, with an average of 1,368 calories. This value, obtained at an altitude of 7,148 feet, is 9.23 percent above the average reported in a previous study by the Oklahoma Station at an altitude of 870 feet, and 10.7 percent above the average reported in a similar study of college women students at Tallahassee, Fla., at an altitude of 160 feet. Of course, other factors such as climate and temperature may also have played a part in the differences obtained in these widely separated geographical regions.

Basal metabolism of older women.—Although there have been many observations of the basal metabolism of young women, comparatively few values have been reported for older women, particularly those over 40 years of age. The Ohio Station has been accumulating data to fill in this gap and has recently reported basal metabolism data for a group of 73 healthy women from 35 to 70 years of age, and of varying size and activity. When the data were classified by 10-year age groups the average metabolism in calories per 24 hours was found to be 1,377 for 18 subjects from 30 to 39 years of age, inclusive, 1,382 for 25 from 40 to 49, 1,297 for 19 from 50 to 59, and 1,128 for 10 subjects from 60 to 69 years, inclusive. The similarity in values for the two younger age groups and the decrease in heat production beyond 50 years of age were found to be equally pronounced when the values were calculated as calories per kilogram, per centimeter per 24 hours, or per square meter per hour. These findings are thought to justify the conclusion that the "basal metabolism of women remains at a fairly uniform level until the age of 50 or thereabouts is reached, after which the heat production declines to a definitely lower level." It is noted, however, that it is very difficult to separate the effects of physical development of the individual from the effects of age. When the heat-production values were arranged by weight, height, and surface area instead of by age the total calories in each instance increased with increasing values. Ac-

tivity was apparently without effect on basal metabolism for the average values for the women engaged in sedentary occupations were approximately the same as for those who were more active physically.

Total energy requirements of women.—From records of the food consumed in 1 day by the individual members of farm families in an earlier study, an investigator at the New York (Cornell) Station calculated the average total energy consumption of 195 farm women to be 2,600 calories per day. Since this figure is somewhat lower than that allotted to farm women in dietary scales and standards used in this country, it seemed of interest to make use of another type of information in calculating the energy requirements of farm women, namely, the time spent by farm women in various tasks throughout the day and the amount of energy required per kilogram per hour to perform these tasks as determined by calorimeter experiments. Previously reported time studies of the Oregon, South Dakota, and Montana Stations, and unpublished data for New York State, contributed by the Bureau of Home Economics, furnished the information on the distribution of time among various activities. As thus calculated, the energy requirement of farm women in these States amounted to 2,602, 2,621, 2,559, and 2,588 calories, respectively, figures in surprisingly close agreement with those calculated from the food-consumption data. Similar comparisons for town and city women indicated a smaller energy requirement, about 2,200 to 2,300 calories. It is thought that the dietary scales and standards of use in this country tend to overestimate the energy needs of women.

TEXTILE AND CLOTHING SELECTION

In the introduction to this section in the 1935 report, various types of research in textiles and clothing which will ultimately benefit the consumer were listed. One of the most technical publications of the present year deals with still another type of textile research, namely, the synthesis of a group of dyestuffs of similar composition and the study of their value as affected by slight differences in chemical constitution.

Fastness of dyes to light and washing.—One of the most important factors to be considered in the selection of a colored washable fabric is its fastness to sunlight and washing. Because comparatively little has been done to determine the extent to which the chemical composition of a dyestuff affects its fastness, this problem was selected for investigation at Ohio State University under experiment station direction. The first study, completed during the year, dealt with the influence of a single chemical group, the sulphonic acid group, in a series of monoazo dyestuffs on their fastness properties. The dyes were synthesized in the laboratory, analyzed, applied to fabric samples of white woolen cashmere, and the dyed fabrics subjected to the necessary tests for fastness to light and washing. As a result of the many tests involved, it has been possible to arrange the series of 10 dyestuffs in order of the combined effects of light and washing, reported as the utility factor. The order of the dyes in this list would be of no significance to the woman interested in purchasing colored fabrics that will not fade nor bleed, but she will profit later if the results of this and similar investigations are given consideration by the dye manufacturers.

Mercerization of wool.—Previous studies at the Iowa Station have shown that the process of chlorination of wool to make it unshrinkable weakens the fabric. Continuing the investigation of the effect of various treatments on wool, the station has found that alkaline mercerization also weakens the wool as measured by weight, nitrogen and sulphur content, dry and wet warp, breaking strength, and elongation at breaking load. In samples mercerized by treatment with 44-percent sodium hydroxide for 5 minutes at 15° C., the dry breaking strength was 95 percent and the wet breaking strength only 40 percent of the corresponding values for the original wool. "The low wet breaking strength of mercerized wool argues against its use." Unfortunately the purchaser of wool fabrics seldom knows the treatment that the wool has received. The report of this study calls attention to the fact that the mercerization process has been used to increase the dyeing properties of wool, to crepe wool fabrics, and to increase the luster of wool.

Effect of steam on silk, wild silk, and wool.—Steam is used in the manufacture of textile fabrics for purification of the fiber, conditioning the fabric, creping, pressing, and setting of twist, embossed design and pile on silk, and for sterilizing and creping wool. The effect of this process on the strength of various fabrics has been tested by the Iowa Station. The silk and wild-silk fabrics were exposed for 1 hour to steam at pressures of 0 to 75 pounds, and for 30 minutes to 5 hours at 60 pounds pressure per square inch, and the wool for 1 hour at 0 to 40 pounds and 1 to 5 hours at 10 pounds pressure per square inch. All of the fabrics were weakened by the steam, the wool to the greatest extent, followed by the wild silk, and finally the silk. Mechanical failure of the fibers was more rapid than the loss of weight, nitrogen, or sulphur, indicating that a break-down of fibrous structure precedes the formation of soluble degradation products.

The effect of salt on silk.—Salt is often said to cause discoloration and weakening of silk fabrics. Since salt is used in some dyeing processes, and is found in human perspiration, a study of the possible deterioration of silk by salt was included in the Iowa textile research program. Samples of pure silk and silk weighted in various ways were soaked in half-normal salt solution at 40° C. for 10 hours and then dried without rinsing and stored in paper envelopes for a year under laboratory conditions, along with untreated samples as controls. Other samples were soaked in a dilute salt solution at 100° C. for 1 hour, dried, and tested at once. The results of the tests on all of the silks showed no discoloration and no appreciable change in the composition in the pure degummed silks after treatment with salt, whether stored or not stored. The weighted salt-treated silks showed no greater discoloration or deterioration than the controls. It was pointed out that these results do not mean that perspiration does not injure silk, but rather that the deterioration is probably due to some other ingredient than salt.

HOUSEHOLD EQUIPMENT

The selection of household equipment from the standpoint of efficiency and economy in use, as well as original purchase price, is an important and sometimes an extremely difficult task in these days of

bewildering variety of equipment and utensils. The problem is receiving attention by several of the experiment stations.

Distribution of cost of electricity in the home.—With electricity available in most rural communities throughout the country, it is being used to an increasing extent for many household operations in addition to house lighting, the first use to which it is customarily put. Electric washing machines, ranges, refrigerators, and vacuum cleaners are the larger type of electrical equipment most commonly used, followed by an ever-growing number of smaller pieces of equipment and gadgets. How do the various items contribute to the total bills for electricity? The best comparison is probably the electrical energy consumed by the different services and pieces of equipment in a given period of time. In order to determine this the Indiana Station several years ago installed different articles of electrical equipment, large and small, in two of their experimental farm homes and in the homes of a number of cooperators. Each article was individually metered and the electric consumption recorded monthly for a period of 3 years in some cases and 1 year in others. From these and other observations the current consumption in an average Indiana farm home for various electrical services and equipment has been estimated to be as follows: House lighting from 10 to 20 kilowatt-hours per month, water pump for house 2.1, washing machine from 0.5 to 4, iron 1.7 to 6.3, ironer 14, water heater of the automatic type 254.3, refrigerator from 33.9 to 63.3, range from 53 to 318.5, sewing machine less than 1, toaster 4, and clock 1 to 3 kilowatt-hours per month. The vacuum cleaner consumed from 1.5 to 2.1 kilowatt-hours per year, the radio 1 kilowatt-hour for from 10 to 20 hours operation, waffle iron 0.1 kilowatt-hour per person per meal, coffee maker 0.16 kilowatt-hour per meal, mixer 1 kilowatt-hour for 10 hours, and 8-inch fan 1 kilowatt-hour for 25 hours' operation.

In comparing these figures one must take into consideration that for some of the services involving the greatest consumption of electricity, such as the electric range and water heater, special low rates are often available, with even lower rates for off-peak hours in some communities.

Electric water heaters.—The high cost of heating water with electricity, as noted above, has led to attempts to effect economies in electric water heaters, particularly in the conservation of heat and in the thermostat control. In a study of the problem at the Washington Station, the question first arose as to the optimum operating temperature for electric water heaters. Information on this point was secured by the station from manufacturers, utility companies, chemists, and users, and some laboratory and home tests were made. It was found that the customary fixed thermostat setting was about 152° F. Temperatures from 140° to 180° were given by chemists and engineers as the upper limit for heating hard water because of the danger of formation of mineral deposits or scale in the heater at higher temperatures. On the basis of these figures, the station concludes that the maximum feasible temperature for heating hard water is under 180°, and that with certain waters lower values may be better.

To determine how these temperatures correspond with the temperatures most satisfactory for various household processes, laboratory and home tests were conducted by the station. For bathing, tem-

peratures from 95° to 103° F., washing hands from 95° to 115°, laundering from 90° to 140°, and dishwashing by hand from 100° to 120° were selected as most satisfactory, while the temperature specification for dishwashing by machine was given as 160°. For most of these processes a thermostat setting lower than the average noted would suffice, while higher temperatures would be desirable occasionally. The possibility of making some saving through manually controlled thermostats were tested by the station in several homes, with results demonstrating the feasibility of such control. Embodying a similar principle, some of the newer heaters are equipped with a double thermostat control for lower and higher temperatures. Others are provided with a special meter and an electric clock which controls the hours when power is available. By thus cutting off the power at the peak of its general use, it has been possible to lower the rates considerably. With all these improvements tending to lower the cost of operating an electric heater, continued use of obsolete types may be more extravagant than the purchase of improved types.

Operating an electric range.—The cost of operating an electric range for identical quantities of the same food will vary with the management of the range and with the utensils used. As the result of a special study by the Maine Station of ways of saving electricity in cooking, practical suggestions to the housewife have been assembled, largely in the form of questions and answers, in an extension bulletin, no. 222, entitled "Introducing the Electric Range." Five easily remembered management suggestions given in this bulletin are: (1) Use high wattage of a surface unit only to bring food to boiling, (2) shorten the time needed for boiling to begin by using a cover on the pan and only a small amount of water, (3) always use a pan which completely covers the heated surface of the unit, (4) try to do as much of the cooking as possible while the heating unit of the oven is hot, and (5) plan to cook more than one food in the oven each time it is used. Some of these suggestions are equally applicable to other types of range.

The Maine investigators are of the opinion that the ideal utensil is still a thing of the future. For top-of-the-stove cooking, the utensil should have a bottom surface capable of absorbing as much heat from the unit as possible, and sides and covers designed to lose as little heat as possible into the room. This means a utensil with a flat bottom, just wide enough to cover the heated surface, and for some materials a rough or blackened surface. The sides should be straight instead of slanting, and there should be a well-fitting cover. At present it is difficult to find flat-bottom utensils that are really flat and that will not warp, although straight-sided utensils are gaining in populariy. The station suggests that the problem of the ideal cooking utensil will be solved if an alloy can be created which shall have a negligible coefficient of expansion (to prevent warping), and shall be—

resistant to corrosion, insoluble in all solutions found in the kitchen, free of any tendency to absorb or retain odors, of such nature or thickness that food will not readily scorch, easy to clean and handle, and reasonable in cost.

Whether or not it is real economy to purchase the more expensive cooking utensils that come closest to the ideal depends, according to the Maine studies, on the type of unit in the electric range, and the

material of which the utensils are made. For closed units pans that are definitely flat on the bottom and heavy enough not to warp badly are more essential than for open units, and their additional cost is justified in the saving of electricity. Black or rough bottom surfaces are not essential for enamel pans, but may reduce operating costs considerably on aluminum pans with units of the calrod or open type.

In the Maine study reviewed above, utensils as purchased on the open market were used, and the efficiencies of utensils and heating units were determined by heating a definite amount of water to a given temperature. In a comparison under way at the Iowa Station of the effectiveness of different types of surface units of electric ranges, a series of 10 different units was mounted in a specially constructed metal box and an iron kettle with thermocouples imbedded in the bottom was used to determine the distribution of heat. In this set-up no difference was found in the distribution of heat by the different units.

Gas ranges.—An investigation at the Nebraska Station of various types of gas ranges on the market, including those of older and more recent design of surface burners, has led to the conclusion that although the surface burners on the modern gas range are superior to the older types, there is still need for improvement. Under identical conditions of size of surface burner and kettle, amount of water heated, and gas pressure, efficiencies of different types of burners were found to vary from 45.5 to 33.5 percent when the gas rate was 9,000 B. t. u. per hour. One stove under these conditions produced excessive carbon monoxide. In the gas ovens studied, the principal fault was found to be in the burner design. It was found impossible to obtain low temperatures of 250° and 300° F. in most ovens because of poor burner design.

Kerosene operated refrigerators.—A comparison at the North Dakota Station of the automatic continuous burner and the refueling type of kerosene-operated refrigerators has shown that both are economical to operate (averaging for farm households 1 quart of kerosene per day), and easily hold a temperature below a maximum of 45° F. Because of the low temperature of 25° often reached in the refrigerator of the refueling type, the station recommends the use of hydrators for vegetables and fruits, and suitable containers or covers for meat, as a means of eliminating excessive evaporation. Timing of preparation of frozen desserts to avoid the temperature rise after refueling is recommended to avoid undesirable changes in volume and texture at the higher temperature. A disadvantage in the automatic continuous burner type is the low level of the adjusting, operating, and cleaning parts.

FARM FAMILY HOUSING

The influence of the Federal Farm Housing Survey noted in the reports for 1934 and 1935 is still being shown in reports coming from various experiment stations.

Farm housing in North Carolina.—The records obtained for the State in the Federal Farm Housing Survey have been subjected by the North Carolina Station to careful analysis and interpretation with rather discouraging results. It is apparent, the station con-

cludes, that large gross incomes from cotton and tobacco areas have not been used for the building of more permanent and comfortable rural homes. Four percent of the houses occupied by white owners, 5.5 percent of those occupied by white tenants, and approximately 8 percent of those occupied by Negroes were considered unfit for human habitation. In more than half of the homes the sanitary facilities were below those required by the regulations of the State Department of Health, and in 30 percent of the cases the condition was a positive danger to health.

Few significant trends toward better houses were found when a sample of houses less than 10 years old was compared with a sample from 25 to 49 years old. The newer houses showed a 3-percent gain over the older in electric lights, and a 2-percent gain in electric stoves. The sanitary facilities were no better, although a slightly larger proportion of the rural houses had bathrooms. The newer houses tended to be somewhat smaller with fewer bedrooms and less storage space for fruits and vegetables; however, more of the houses had living rooms. Only 1 family in 6 expressed a desire to borrow money at satisfactory interest rates for home improvement, and only 1 in 10 said that money for home improvement was available from local sources. As a help when conditions make home improvements feasible, the station has prepared a list of minimum rural housing standards for North Carolina farmhouses.

Factors affecting farm housing.—The two recent housing surveys in Iowa noted in the 1935 report have aroused much interest in housing problems in the State, and many questions have been asked as to why the dwellings are not in better condition, with better facilities, and what can be done to improve them. To answer some of these questions the station has made a further analysis of the situation, and has summarized in outline form the major factors considered responsible for present defects in housing, with suggestions in considerable detail of possible lines of action for families and organized groups to improve existing conditions. The five reasons given for poor housing are low money income; high proportion of tenancy; high costs of materials, labor, fire insurance, credit, and taxes on housing improvements; lack of adequate facilities in electricity, architectural services, and sources of information; and poor attitude and knowledge of the family concerning good housing and how to acquire it. In the opinion of the station, education, especially adult, has an important part to play in a program of housing improvement.

Farm-home construction.—It was noted in the 1935 report that preliminary studies at the Arkansas Station on the use of home labor and material in the construction of farmhouses in the State indicated that more than 50 percent of the value of the house may be contributed by the farm in labor and materials. This has been substantiated by the complete analysis of the cost of a modern rural home representing an actual cash outlay of $2,084.14 for a house that would be valued at $4,630 if built by contract under nearby urban conditions. Home contribution of labor and services accounted for $377.87. A saving of $375 was effected by the use of rural carpenters living in the community. The management of the construction work by the owner, with credits for carlot purchases, competitive bidding, and careful attention to details, was valued at

$437. The additional saving over urban costs was gained by the use of native and local materials, and the absence of complicated restrictions and regulations.

CONSUMPTION HABITS OF FARM FAMILIES

While reports continue to appear on the adjustments made in farm family expenditures under the falling incomes of the depression, others are beginning to appear on the effects of rising income on the various types of expenditure. An example from each will be noted by way of contrast.

Changes in consumption during a depression period.—In 1932 the Michigan Station obtained information on the consumption habits of 114 farm families in a single county of the State during that year and in 1929. The analyses of these records give some insight into the way the farm families made adjustments to a change in cash income from an average of $1,353 per family (4.4 persons) in 1929 to one of $664 in 1932. The changes in food consumption were relatively slight as measured in terms of quantities and retail valuation adjusted to changes in the price level. The total amount of foods increased 1.8 percent, while the adjusted retail valuation increased 2.5. The proportion of food purchased decreased 18.4 percent in amount and 8.7 in valuation. The proportion furnished from the farm increased 1.5 percent in amount and 6 in retail valuation. There were increases in milk, cream, and vegetables used, but decreases in fruit due chiefly to variation in apple production. Clothing expenditures per family decreased 32.9 percent. Expenditures for repairs and improvements in housing decreased 59 percent. There were fewer additions and replacements in 1932 than in 1929. The use of wood for heating increased 7.5 percent. There was an increase in use of electrical and mechanical equipment of 31 percent in washing machines, 35 in electric irons, and 13 in vacuum cleaners. There was a decrease in number of life insurance policies carried, but a slight increase in the average size of policy.

First changes made consciously by families were predominantly in increase of home production of food and purchase of cheaper foods, in curtailing of clothing expenditures, in less use of car, in fewer entertainments, and removing the telephone. An actual important change was in the nonpayment of financial obligations, although that was not listed as a conscious choice.

Changes in consumption with rising income.—Among the many farm families in Illinois now enrolled in account keeping through the efforts of the experiment station and extension service are 84 families that have kept accounts for 4 consecutive years, 1932 to 1935, inclusive. These 4-year records have been analyzed by the station in order to note the changes in consumption habits with rising income, and to obtain suggestions for long-time budgeting of items which need be included only occasionally. Although the average realized income of these 84 families increased during the period from $1,349 per family in 1932 to $1,849 in 1935, the trend toward increased income occurred in only 69 percent of the families. In 5 percent the realized income decreased each year, in 5 percent it remained practically the same, and in 21 percent it fluctuated during the 4-year period.

Considering averages only, there was an increase in all divisions of spending between 1932 and 1935, but between 1934 and 1935 there was a decline in savings other than in life insurance premiums, which increased from an average of $125 per family in 1932 to an average of $134 in 1935. Aside from food expenditures to be noted later, the expenditures which showed the greatest increase in the 4-year period were for shelter, automobile, and clothing. Actual cash expenditures for shelter, including repairs and furnishings, were three times as large in 1935 as in 1932. In 1934 repairs came first, but in 1935 more money was spent on new equipment for the home than on repairs, with electric stoves, refrigerators, and washing machines frequent items of large equipment purchased during the year. None of the 84 families purchased an automobile in 1932, 1 purchased in 1933, 11 in 1934, and 16 in 1935. The fact that only one-third of the families in this group bought a new car or later model during the 4-year period is cited as showing that "longer time records are needed in order to ascertain how to distribute properly the cost of a new car, or what replacement allowance to make per year." More money was spent for clothing in 1935 than in each of the previous 3 years. The increased expenditure went into more articles rather than higher prices. Many more coats, for instance, were purchased in 1935 than during the previous 3 years.

When the group was divided into thirds, according to low, medium, and high realized incomes, an interesting finding was noted concerning food costs. For each of the 4 years the average daily cost of food per adult in the lowest income group was less than that for either of the other two groups, and the percentage of home-grown foods was highest. In the other two groups the advances in food costs were much greater than the price-level changes. The inference is that at certain low-income levels there is a tendency to control purchased-food costs even with increasing income (in this group the average income increased from $905 to $1,232), while this does not hold for the higher income groups.

From the 1935 records of the Illinois study, totaling 139, the price ranges and averages of principal items of clothing for farm operators and homemakers, housing repairs, furniture and furnishings, and home equipment have been assembled as a guide in budget planning. Such long-time studies as this one in Illinois are invaluable, particularly to those cooperating in the project by keeping accounts year after year.

Sybil L. Smith.

RURAL ECONOMIC AND SOCIAL CONDITIONS

This statement, dealing with results of studies in agricultural economics and rural life, relates primarily to work under way in previous years rather than to points of emphasis in the present year. A better perspective of the types of research programs under way and subjects emphasized during the current year may be had by reference to the distribution of projects and the nature and extent of cooperation among the State stations and between them and Federal agencies, elsewhere presented in this report.

Agricultural adjustment, in the sense of improving cropping and grazing systems relative to land use, soil conservation, and net in-

come, continued to be a subject of dominant interest among the State agricultural experiment stations during the year. This effort consisted of a synthesis of available information, previously begun cooperatively by the Bureau of Agricultural Economics and the 48 State stations, and of studies of unsolved problems. In this work, practically all types of subject-matter specialists, State and Federal, participated cooperatively even to a greater extent than in previous years.

In the field of agricultural economics, the distribution of research projects active during the year was as follows: Out of 393 projects, 96 were in farm management, 78 in marketing, 52 in agricultural adjustment, 41 in land economics, 35 in taxation, 30 in prices, 27 in rural finance, 17 in rural-business analysis, 11 in cooperation, 4 in tenancy, and 2 in miscellaneous studies. It is of interest to observe that no projects were reported dealing with rural insurance under way on Federally provided funds.

In rural sociology, the emphasis seemed inadequately reflected by the projects under way. A better view may be obtained from the projects participated in cooperatively by the State stations and Federal agencies, including the Bureau of Agricultural Economics, the Agricultural Adjustment Administration, the Resettlement Administration, and other regular and emergency agencies. Collectively, these agencies dealt aggressively with problems affecting better rural living, including studies of the rural family, community studies, rural population, rural organizations, rural social institutions, and rural welfare. At the State stations, some 55 rural sociological projects were active during the year, while the stations participated cooperatively in a large number of Federal projects initiated by the agencies mentioned above.

The following summaries of results of research in agricultural economics and rural sociology at the State experiment stations are presented to indicate some of their contributions to essential knowledge of adjustments in agriculture and rural life:

ECONOMIC CONDITIONS

LAND USE AND FARM MANAGEMENT

Good versus poor farming.—The Illinois Station reports that the gap between good and poor farming is widening. In a study of the subject the station found that the one-third of the farms making the best average annual net incomes received $1,786 more income annually than did the one-third of the farms having the smallest income. This difference of $1,786 annually, or a total of $17,860 over the 10-year period, is to be accounted for through differences in the efficiency of farm organization and operation and not to differences in size of farms operated. It seems apparent from this and other studies that the margin between good and poor farming on the same kind of land originally is gradually becoming greater, especially as the depletion of the soil becomes more pronounced.

A profitable long-time farm management program.—A study by the Kentucky Station indicated that when improved organization and practices have time to be reflected in yields, production, and unit

costs, an average increase of $400 a year per farm can reasonably be expected on representative farms.

Land ownership and land use planning.—A study of land ownership by the Montana Station disclosed that 44 percent, or about 41,000,000 acres, of the agricultural land area of the State is owned by public agencies—the Federal Government 35.6 percent, the State 5.7 percent, and counties 2.7 percent—14 percent by corporations, and the remaining 42 percent is owned by private individuals, of which 30.8 percent is owned by residents of the State and 10.9 percent by nonresidents. Fundamental maladjustments are indicated by tax deeds and mortgage foreclosures, due in part at least to overspeculation in land, overdevelopment of local government, and improper land utilization.

Progress is being made in land-use planning in four principal ways: (1) Consolidation of farms by the more successful farmers taking over lands abandoned by their less successful neighbors; (2) the voluntary grouping of ranchers to form cooperative grazing districts and thus acquire effective control of a given area; (3) establishment of adequate control of the public range through the Taylor Grazing Act; and (4) blocking out into economical units by outright purchase of most of the numerous small privately owned tracts in selected areas by the Federal Government.

Land use in Pennsylvania.—Cooperating with the Department of Agriculture, the Pennsylvania station made a study of land use in that State for the purpose of classifying the soils as a guide to their most economical use. In general the station observes that as Pennsylvania agriculture has become more commercialized and the use of large-scale machinery more common, the tendency has been toward more intensive farming on the higher grades of land and toward a less intensive agriculture on lands of the lower grades. It is probable that these trends will continue.

Farm land valuation in Missouri.—From a study of factors affecting farm land values in Missouri, the Missouri Station concludes:

> From the viewpoint of the valuation of farm land, the important inherent characteristics are such things as the nitrogen and available phosphorus content of the soil, soil structure, particularly clay or hard pans, and its topography. * * * These unit factors may be used as a basis for grading land, and there is reason to believe that such grading would correspond very closely with gradations in actual productiveness of the land.

Other factors affecting land value are—

> those arising from location and special aspects of the community in which the land is found. An important factor influencing land values is the capitalization rate. In Missouri capitalization rates are, in general, high in areas of poor and low in areas of good land, as measured by varying levels of the above inherent features of land character. Taxes of both the general and special assessment kind exert a further powerful influence. * * * Erosion is a powerful land value depreciating force in Missouri, and no appraisal is complete until some effort has been made to forecast the future effects of erosion on the value of the property being evaluated.

Land appraisal.—The recent extensive use of soil maps in land appraisal has emphasized the need for assistance of trained soil men in evaluating various types of soil. The Ohio Station has worked out a schedule of land values in relation to corn yields which gives an approximate basis for estimating land values in terms of productive capacity. The method has value especially in that it takes into

consideration the system of soil management as well as the inherent productivity of the soil type.

Types of farming in Colorado.—A study of type-of-farming areas in Colorado

> to acquire a more comprehensive understanding of the agriculture of the State as a whole; to locate and delimit the different type-of-farming areas within the State; to determine the general character of the farming carried on in each area; and to identify and evaluate the relative importance of the various forces and conditions which have been and are now shaping the type of farming in the various parts of the State

has recently been reported by the Colorado Station cooperating with the Department of Agriculture. "The method of study has been historical, graphical, and analytical." It was based on census data for 1929 and also on independent observations. Since 1929—

> a period of extremely low rainfall years has occurred and it has been apparent that some of our land utilization plans have been fundamentally unsound. An attempt has been made to grow crops on lands which, under recent conditions, would have been better adapted to grazing. If maximum returns are to be secured from these areas in future years some abrupt adjustments should be made. Recent studies have indicated the necessity for such changes.

Types of farming in Puerto Rico.—The varied types of soils in Puerto Rico and their crop adaptations, possibilities, and present use have been studied and defined by the Puerto Rico (Insular) Station. The station says:

> In every section there are a number of competing factors—physical, economic, and social—that enter into determining the type of farming that can be followed most successfully in that region. It is important to realize the great influence exerted by these factors and not to assume that any kind of farming can be carried on successfully in any region; that the farmer who most fully realizes these various forces and works in harmony with them, will in the end obtain a higher financial return than those who go on the assumption that they can produce what they desire wherein and wherever they wish to farm.

Farm cost of potato production.—In an economic study of potato growing in Michigan, the Michigan Station found the farm cost of potato production, not including marketing, to be $43.22 per acre, or 34 cents per bushel of table stock with an average yield of 126 bushels per acre, and $82.81 per acre, or 34 cents per bushel for certified seed potatoes with an average yield of 241 bushels per acre. The average costs per acre ranged from $19.48 to $134.55 for table stock and from $29.38 to $154.96 for certified seed potatoes. Factors tending to increase yield and lower costs were fall plowing, early planting, use of good seed and suitable fertilizers, efficient use of labor and power, and thorough cultivation and care.

The economics of apple production.—From a study of costs of producing apples in commercial orchards, the New Jersey Station reported on a basis of data obtained in Burlington County over the 5 years 1930–34 an average return above cost of production of approximately 10 cents per bushel per year. The average yield of the orchards under observation was 165 bushels per acre.

A change in the apple situation was noted by the New Mexico Station and indicated that growers were planting better varieties and receiving better prices than in former years. Recent plantings were largely of the Rome Beauty, Delicious, Starking, and Stayman Winesap varieties. Of these, Delicious sold at the highest price followed next by Rome Beauty. There was an evident decline in the

size of the apple industry in New Mexico, with indications that this reduction would be continued until it reached the point where production was adequate to supply the demands of nearby markets.

The economics of bean production.—The bean is one of Michigan's leading cash crops, having an average annual value of $14,000,000 during the 10-year period 1924–33. The Michigan Station found that farmers in Michigan keeping cost records on pea beans during the 4 years 1929–32, had an average of 24 acres of beans per farm. Total cost per acre averaged $29.47. The average yield per acre was 13.2 bushels. Total income from beans and pods (using Dec. 1 price) was $27.97 per acre. The charge for labor, power, and machinery use made up 43 percent of the total cost, while the land-use charge constituted 22 percent, manure and fertilizers 15 percent, seed 10 percent, and threshing and other costs the remaining 10 percent. Net cost per 100 pounds of field-run beans averaged $3.57, and the average December 1 farm value was $3.38 during the period of the study. Return per hour of labor on the bean crop on these farms with an average 13.2-bushel yield per acre was 20 cents an hour, even though the index of farm costs averaged 146 and the index of bean prices 103.

The one-third of the pea bean growers having the lowest yield each year of the study had an average production of 8.9 bushels per acre during the study. Beans produced on these farms cost $4.87 per 100 pounds (field-run), and there was a loss of $7.12 an acre. Growers in the high-yield one-third averaged 19.9 bushels per acre. On these farms the beans cost $2.58 per 100 pounds (field-run), and there was a profit of $7.47 an acre. Factors found to be instrumental in causing the higher yield were good drainage, early planting, Robust variety, and wise use of manures and fertilizers.

Milk-production costs.—In a study of milk-production costs incurred by 51 farmers in the Morgantown and Fairmont market areas, the West Virginia Station found that the total cost of keeping a cow a year averaged $125.14 in the Morgantown area and $109.26 in the Fairmont area. Feed and labor costs were $74.80 and $24.74, respectively, in the Morgantown area. The costs of all other items totaled $24.60. In the Fairmont area feed cost per cow was $67.94 and labor cost $22.95. The remaining costs totaled $18.37. The total cost of producing 100 pounds of 4-percent milk was $2.15 for the Morgantown market and $2.14 for the Fairmont market. Feed was the largest item of expense, amounting to $1.29 per 100 pounds of milk for the Morgantown area and $1.34 for the Fairmont area. Labor costs were next in importance, amounting to 42 cents per 100 pounds of milk for the Morgantown market and 45 cents for the Fairmont market. The amount of labor required depended mostly on the size of the herd. The remaining costs totaled 44 cents per 100 pounds of milk in the Morgantown market and 35 cents in the Fairmont market.

In the Morgantown milk-production area the man labor per 100 pounds of milk was 2.5 hours. In the Fairmont area and on most of the farms in the Morgantown area the producers did not receive a price for their milk sufficient to cover costs of production. Greater care in grain feeding and greater use of legume hays are suggested as means of reducing costs of production.

MARKETING

Organized versus independent marketing.—From a comparative study of organized versus independent marketing of apples, the Washington Station concluded that marketing organizations, if well managed, are capable of helping members in three ways—by reducing marketing costs; adjusting price to market demand, and under favorable circumstances to some degree adjusting supply to demand; and by developing and extending markets. While there have been many failures of cooperative marketing associations, the station states that there are outstanding examples of cases in which the objectives named have been attained.

Cooperative marketing of farm products.—The operations of 170 cooperative marketing associations in Washington having a total membership of 40,000 and a total business of $50,000,000 in 1934, mostly selling but also some buying, have been studied by the Washington Station. The station concluded in general from the results of its studies that while cooperative marketing is not a panacea for the ills of agriculture, in many instances it has been the means of attaining substantial benefits for Washington farmers. It points out, however, that cooperative marketing organizations need to be wisely managed in order to give maximum benefits. Among the factors which the station says have contributed greatly to the success of the Washington cooperatives are the following:

> An adequate volume of business; conducting operations in such a manner as to furnish dealers and consumers an improved product of highly standardized quality; economical operation; intelligence and effectiveness in selling; an adequate and accurate system of accounting; adherence to the principles required to be observed in order to be recognized as a cooperative association under the Capper-Volstead Act and by the Farm Credit Administration; [and] a sound financial program, including a substantial investment by the association's members in the assets needed to conduct its operations, and a financial interest in the association by its entire membership.

Efficiency of local grain elevators.—Among 79 elevators included in a study by the Indiana Station were 10 grain elevators receiving an average annual net income of $4,057 and 10 side-line elevators showing an average net loss of $1,559 during the depression years 1929–33. The efficiency of operation of grain elevators was greater than of side-line elevators. The former received $798 less gross income but $1,139 more net income than the side-line elevators. Farmers patronizing successful elevators tended to receive maximum prices for grain and to buy side lines at minimum prices. The most important factor in accounting for variations in efficiency of operation was volume of business. The efficiency of operation increased fastest until a volume of $120,000 worth of business was handled. The easiest way to increase efficiency in operation was to utilize labor and management fully, since these constitute nearly one-half of the total cost of operating an elevator. Proprietorship frequently did not appreciate fully the value of superior management. Twelve of the seventy-nine managers and proprietors each received salaries of $2,100 or more. They showed an average net profit of 42 cents per dollar of salary, as compared with an average net loss of $1 for the 12 managers and proprietors each receiving $1,200 or less. None of the elevators hedged closely or consistently

to protect grain-trading margins. Many speculated on grain and lost heavily. Local elevators shared the depression with farmers. They substantially decreased their trading margins and also their expenses. There was a big difference in the extent to which different elevators had become adjusted to the changed economic conditions. Those having the largest proportion of variable costs found it easiest to make adjustments.

Farmers' elevators.—The Iowa Station found answers to the questions, What's wrong with Iowa's farmers' elevators and what can be done to improve the membership situation? It was found that some of them were not cooperatives but operated merely as "another buyer"; many of them had too few members, in 1931 three-fourths had only from 50 to 200, the range for all elevators being from 23 to 681 members. Of 40,887 members of 314 elevators studied, nearly a fourth (23 percent) neither owned nor operated local land and less than half of all members owned the farms they operated. The proportion of nonproducer members was increasing because of the difficulty of shifting the stock of those who ceased farming to new members. The control, therefore, of many farmers' elevators is no longer in the hands of producers.

The total number of members was decreasing. Disloyalty of members of farmers' elevators is commoner than formerly. There is too much laxness in carrying out provisions of articles and bylaws and too little advantage taken of cooperative laws.

Remedies suggested are: Make memberships easy to acquire and easy to terminate; keep the par value of shares low; prorate savings as patronage dividends; make membership more easily acquired by the application of patronage dividends on purchases of shares; provide for transfer of shares from nonproducers to producers; limit membership to farmers; make the farmers' elevators the sales agency of its members and thus encourage nonmember producers to become members; and reorganize if necessary.

Cotton-marketing practices.—Recent studies by the North Carolina Station of cotton-marketing practices in North Carolina have shown that the value of cotton based on grade and staple is determined after it passes from the ownership of the producer. In the Piedmont area 66 percent of the cotton is bought by ginners who are unable to class cotton. In the Coastal Plain area 38 percent and in the Tidewater area 44 percent of the cotton is marketed through the ginner. This system of marketing does not promote standardization or improvement in quality. As a result of the studies the station has proposed alternative marketing methods.

From a broad study of local cotton markets and methods of marketing in North Carolina, the North Carolina Station finds that factors having an important influence on the local markets are—

the proximity of local buyers to mills and export markets; the contacts of local buyers with mills and cotton merchants; the importance of cotton as a crop in the community; types of farming and sizes of farms; grade and staple of cotton grown; variations in both grade and staple lengths of the cotton grown; the volume of local buyer purchases; the lack of ability to classify cotton accurately on the part of both buyer and the farmer; the established trading practices; credit facilities for both the farmer and the local buyer; and the economic independence or dependence of producers.

There was found to be little uniformity in quality of cotton offered for sale in most local markets. Cotton is bought on the average and sold on the average. Consequently—

the higher grades and longer staples are penalized by the lower grades and shorter staples sold in the same market. An average price fails to encourage the production of higher quality cotton. Consequently, cotton of a lower grade and shorter staple is produced. As this is done the average price is decreased and the total returns for the community are lowered.

The station thinks—

there would be greater standardization in grade and staple produced if the proper price was paid for the different classes. The demand for American cotton relative to foreign produced cotton probably would be greater if the quality of American cotton was improved.

The station suggests the advantages of a type of market in which—

each bale would be sold on its individual class and "hog round" buying would be eliminated. Producers of high quality cotton would obtain greater compensation for their efforts. It would eliminate extra shipping to find a place for the different grades and staple lengths. Cotton would be a standardized commodity that any person could buy and sell. The cotton buyers' success would depend more upon business ability than his knowledge of cotton. Any effort to improve the marketing system would be greatly assisted by the establishment of one variety communities.

Cotton prices and quality.—From a study of farm prices of cotton, the Missouri Station found that—

prices to growers in selected local markets in Missouri varied so irregularly on the basis of grade and staple length during the seasons 1929–30 to 1933–34 that it was not unusual for some farmers to receive considerably higher prices for lower grades and shorter staples than other farmers received for higher grades and longer staples sold in the same local markets on the same day. On the average, prices received by growers for the lower-grade and shorter-staple cotton were about the same as the prices received for cotton of higher grade and longer staple sold in the same markets on the same days; while in central markets prices for the higher grades and longer staples were considerably higher than for the lower grades and shorter staples. Lack of knowledge of the correct classification and commercial value of cotton, inadequate volume of some of the grades and staple lengths, differences in bargaining power of farmers and of local buyers, and the former practice of selling seed cotton, are considered the principal factors responsible for growers not receiving in local markets a larger proportion of central market premiums and discounts for grade and staple length.

Public produce markets.—The Michigan Station reports that the number of public markets in the State increased from 8 in 1920 to 34 in 1933. The sales on four wholesale markets constituted about 60 percent of the $17,200,000 of produce sold on all markets in 1930. Retail markets were most successful when located near centers of population and where parking facilities were adequate. A city of 10,000 is large enough to support a retail market 1 day a week, but a city of 50,000 could support two retail markets located in different sections of the city and operated on alternate days. The success of the markets was more dependent on the system of administration than on the type of ownership and control. Most consumers prefer to buy at the public markets, where they have an opportunity of comparing and selecting from a wider variety of produce, than from the limited supply offered by hucksters and farmers who sell at the city residences. The final test of the economic soundness of a public market is whether certain services of distribution can be sup-

plied at a lower cost when produce moves through it than when distributed through other channels.

Farm prices and returns for truck crops.—An analysis by the New Jersey Station of farm prices and returns for the years 1919 to 1934, inclusive, of a number of important truck crops for fresh market shipment, in competition with products from other parts of the country, showed a very marked increase in both acreage and production, with a decided increase in farm prices and returns per acre during that period. The increases were found to be much larger in distant areas than in the Northeastern States. In the Northeastern States the recent trend in the vegetable industry has been toward a more direct method of distribution. Approximately one-third of the total volume of fruits and vegetables produced in this area is now sold through large retail selling organizations. The station warns that the mere fact that the New Jersey vegetable grower is located in close proximity to the world's largest markets is not sufficient to insure him a living wage. In the opinion of the station, the chief objectives of the New Jersey vegetable industry in the next few years must, therefore, be high quality and low production costs.

Precooling and shipping asparagus.—"Precooling of California asparagus before shipment to eastern markets", says the California Station, "has become an established commercial practice because it secures a reduction in transit refrigeration costs and if well done assures a satisfactory condition on arrival." In experiments reported by the station, the transit temperature of a precooled car averaged 45° F. the first day and 47° the first 4 days, as compared with 61° and 56°, respectively, for a nonprecooled car. Temperatures in the nonprecooled car were more favorable for spoilage organisms and indicated nearly twice as great a respiration rate, which would produce enough heat for meltage of 2.5 more tons of ice. The ice required to cool a carload of asparagus from 70° to 40° in 12 hours, aside from refrigeration lost through the car, was estimated at 6,500 pounds, the heat of respiration accounting for about one-third of the total. In actual tests 7,000 to 7,500 pounds was melted. With an air-circulation rate of 3,000 cubic feet per minute at each end of the car, the load was brought to 40° in 70 percent of the time required for 2,600 cubic feet per minute. Various improvements in equipment and operation are proposed.

Production-consumption balance of fruits and vegetables.—The Michigan Station reports increases in the production of sour cherries, grapes, cantaloups, strawberries, celery, onions, and tomatoes, while the trend of production for apples, peaches, pears, and plums indicates little if any change. There was a decline in the cabbage and potato production.

Shipment to other States was an important source of farm income. Between 1929 and 1933 Michigan shipped out 33 percent of its apples, 6 of its red cherries, 26 of its sweet cherries, 30 of its peaches, 39 of its pears, 72 of its grapes, 65 of its strawberries, 13 of its cabbage, 58 of its cantaloups, 72 of its celery, 81 of its onions, 14 of its potatoes, and 42 percent of its tomatoes. Of the volume of receipts of each of the fruits and vegetables studied, 1930–33, apples received from other States amounted to 44 percent, sweet cherries 25, peaches 21, pears 46,

plums 37, grapes 24, strawberries 16, cabbage 8, cantaloups 19, celery 10, onions 54, potatoes 31, and tomatoes less than 1 percent.

Truck transportation.—In a study by the New York (Cornell) Station of costs and methods of operation of commercial trucks in transporting fruits and vegetables to market in nine States, conducted in cooperation with the Farm Credit Administration, it was found that commercial trucks were of major importance for hauls of 300 miles or less. With rare exceptions, truck transportation was superior to rail transportation for all distances within the scope of this study. Express was the only type of rail service that even approximated the speed of truck service. Costs of operation for commercial trucks ranged from 1.2 to 34.7 cents per ton-mile and averaged 3.8 cents. The station suggests that in determining the type of transportation to be used, cooperative associations should consider the question of operating their own fleet of trucks. Very few associations owned trucks. Yet, in many instances, associations could have moved their fruits and vegetables to market more economically in their own trucks than by having commercial trucks do it.

Increasing demand for meat.—Convincing evidence of the way in which higher incomes increase the demand for foodstuffs is found in a bulletin recently published by the Minnesota Station. The close relation between revival of business and city-consumer demands for meat is materially benefiting the meat producers.

American lard in foreign markets.—Lard, says the Iowa Station, is by far the most important export product originating in the Corn Belt. It is through lard that this region is tied into world markets. Chiefly because of the large volume of lard usually exported, the equivalent of more than 10 percent of the production of the Corn Belt enters foreign trade.

Milk-distribution costs.—A comparison made by the West Virginia Station of the milk-distribution costs of 75 producer distributors with those of 9 commercial plants in the same territory revealed substantially lower total costs on the part of the former class. Reasons given are: (1) Lower average wage rates of the producer distributor along with (2) no pasteurizing costs and (3) lower investments in real estate and equipment per hundredweight of milk sold, (4) plants had to market a larger proportion of their milk as surplus milk, and (5) plants did not meet their costs for special services to consumers. Because of relatively small investment and large percentage of labor which is family and operator's labor, the producer distributor can adjust his costs to price more readily than can the commercial plant.

Butter consumption.—The Kansas Station reports a study of factors affecting the butter consumption from which it appears that the retail price of butter and consumer income are the most important factors affecting consumption.

> It will always be possible to get large quantities of butter consumed if farmers are willing to take the low price necessary to move large quantities of butter into retail channels. Large per-capita consumption seems possible only after prices are lowered to a point where the consumers, at their current income levels, can afford to take the total quantities offered. Excessive butter production will result in higher levels of consumption and also in low prices. * * * When butter prices rise above a certain point, some of those who normally use butter shift to margarine. This increases the demand for margarine and its price increases. Oleomargarine does not compete directly with butter because

of price differences, and if margarine were not available to those who cannot afford butter it is likely that many of them would use lard, vegetable oils, or some other substitute.

TAXATION AND USE OF TAX FUNDS

Taxation trends as related to agriculture.—The present trend in taxation in Arkansas, the Arkansas Station says, is—

> definitely in the direction of finding a specific basis for taxes. While the net income tax is a part of the system, it has never been accepted as a primary source of revenues. The general property tax is tolerated, with all of its administrative weaknesses in full force, because as yet no adequate substitute, from the viewpoint of the public at large, has been found.

The State and the people of the State have been reluctant to accept the income tax and other of the better forms, or to support strict enforcement of existing tax laws. There appears to be a tendency to have practically all of the newer taxes levied and collected by the State rather than by the local governments.

> Much of the revenues, however, is used to subsidize public services under local administration. In other words, most taxes are levied and collected by the State, but a growing percentage of the revenues is being distributed to local divisions. * * * The effect of these developments is for the most part favorable to farmers. Shifting the tax to goods produced or sold, with farm products usually exempted, results, in terms of the whole volume of taxation, in relative tax relief of farmers. This is especially true in the case of the taxation of natural resources, sales, incomes, and some of the special bases used for taxing business. Farmers do not pay such taxes and are less likely than other groups to bear all or a portion of them as a result of tax shifting. And what is even more important, as the volume of revenues is thus increased public services for the benefit of farm people are improved.

State laws have been enacted which will eliminate the use of mere technicalities for invalidating tax titles, but provide for more adequate enforcement of the personal-property tax. There is indication also that stricter enforcement of special tax laws is being applied.

Public revenue with special reference to rural taxation.—The Ohio Station reports that the Federal internal revenue collections in Ohio were $4.99 per capita in 1913, $64.89 in 1920, $9.06 in 1932, and $17.81 in 1934. Total revenue collections of Ohio's State and local governments in 1933 were 3.37 times as high as in 1913, whereas per-capita collections in 1933 were 2.47 times as high. The general-property tax has declined in relative importance, yielding 57.78 percent of the total State and local revenue in 1933, compared with about 80 percent in 1916. The general-property tax and special assessments are the main support of the local governments, although important aid comes from the motor-fuel tax, motor-vehicle licenses, and miscellaneous sources.

The local public debt increased steadily from 1910 to 1929 and then showed a tendency to decline. Local governments have inadvisedly pursued the policy of borrowing when prices were high and, of course, had to pay when prices were low. In 1925 educational costs represented about 40 percent and highways 26 percent.

Since Ohio adopted the policy of tax-rate limitation in 1910, demands for increased public service have been more insistent than for tax reduction. Extensive property-tax delinquency indicates a partial break-down of this form of taxation.

Farm taxes have been reduced one-half since 1929 but are still higher in terms of things farmers sell than they were in 1914.

Prices of Vermont farm real estate.—The Vermont Station has found that—

> During the period from 1928 to 1933 Vermont farms were appraised for taxation on the average at 75 percent of their sales value, but forest land, uncultivated land, and farm land without buildings were appraised at approximately their full sales value. Farms which sold at relatively low prices per acre were appraised at higher rates compared to their sales value than were more valuable farms, those worth less than $10 an acre being appraised, and taxed, at twice as high a rate per dollar of sales value as were those worth over $40 per acre. * * * Vermont farm real estate prices rose from 1900 to 1920 and have since declined. At the peak they were 50 percent above the pre-war, 1910–1914, average. In 1933 they were approximately at the pre-war level.

Tax assessment.—An analysis of tax assessments in 28 Virginia counties by the Virginia Station showed the ratio of assessed to sale value of properties sold in 27 Virginia counties in 1930 to be extremely variable between classes of property, political units, and individual properties. The extreme range in assessment ratio was from 0.25 percent to 385 times the sale value of the property. Sale value per acre was the most important factor associated with the ratio of assessed to sale value. Properties of relatively low sale value per acre were found to be overassessed in relation to properties of relatively high sale value per acre.

As a means of correcting this situation, the station suggests

> the establishment of a nonpolitical taxing authority manned by a hired personnel employed on the basis of qualifications for scientific appraisal of real estate values and operated continuously under the supervision of the State Tax Commission. Such an office or department in the county government could continuously collect, file, and correlate information concerning sale values of property and continuously revise assessments on the basis of sale value or any available information concerning income-producing capacity.

The station says that—

> until some such sort of continuously functioning scientific tax authority is in operation, wide variations in property tax burdens will persist, complaints will arise, and boards of equalization will be compelled to cope ineffectually with an undesirable and unjust situation.

Similar results and conclusions have been reached by the South Dakota Station.

Inequalities in income taxation.—On the basis of a study of more than 50,000 income-tax returns of farmers, merchants, realtors, and retired business men in South Carolina, the South Carolina Station concludes that—

> in some cases more than half of the net incomes for these groups has been absorbed by taxes as a result largely of unprofitable property investments. In many instances, taxes have required more than 25 percent of the net income of this group.

At the other end of the scale were found miscellaneous employees, nurses, preachers, teachers, auditors, bookkeepers, etc., who pay little or no taxes on property, which accounts in large measure for their relatively low rate of taxation.

Taxation of tangible versus intangible property.—The Texas Station found gross inequalities in the taxation of tangible as compared with intangible property in Texas. It states that almost all intangible property such as stocks, bonds, mortgages, notes, cash in hand,

cash on deposit, etc., escapes the payment of direct taxes. The station finds that tangible property constitutes 51.1 percent and intangible property 45.9 percent of all property probated in the State, while tangible property constitutes 97.1 percent of the property assessed for taxation and intangible property 2.8 percent. Tax delinquency on farms is high and increasing and sales for delinquency are low. The risk of losing the farm from a failure to pay taxes being no greater than it is, in the opinion of the station, is undoubtedly the cause of the failure to pay. The station suggests the need for certain changes, not only in the administrative and legal aspects of taxation, but in the fundamental bases of taxation with a view to a greater equalization of taxes.

The average tax per acre on farm and ranch real estate rose gradually from 8.4 cents in 1913 to 26 in 1931, and fell to 19.6 in 1933. Concurrently, the prices of farm products in Texas rose from the base level (100 percent) in 1913 to 222 percent in 1919, the highest point reached by prices during the period of 21 years. From this high level prices declined to 51 percent in 1932, the lowest point of the period, and recovered to 64 percent in 1933. These two forces—rising taxes and falling prices—resulted in a tax on farm real estate in 1933 relatively 3.6 times that of 1913.

Farm tax delinquency.—Studies on tax delinquency, based in large part on a nation-wide project financed by the Civil Works Administration in which all the stations cooperated with the Department of Agriculture (B. A. E.), have been reported by a number of the stations. Farm real estate tax delinquency has both short- and long-time aspects, according to studies at the Kentucky Station. Short-time delinquency appeared to be affected most by current prices of farm products, and increased with falling prices and decreased with rising prices. Long-time or chronic delinquency, on the other hand, appeared to be influenced most by natural factors. In other words, there is less such delinquency in the better farming areas. Type of farming also affects tax collections. Delinquency was found to be less in areas producing intensive crops.

From a study of tax delinquency in Maryland, the Maryland Station concluded that "there are so many factors associated with the extent of tax delinquency that it is difficult to ascribe the lack of paying taxes on time to any outstanding cause", but the station is of the opinion that "promptness of tax payments seems to be encouraged by the use of discounts. The data suggests that discount privileges have a greater influence on promptness of payment than does the penalty attached for late payment." The station finds a distinct need for clarification and uniformity of the laws regarding tax sales and that tax delinquency is not necessarily a direct reflection of the marginality of land.

The Michigan Station made a study of tax delinquency in that State, which showed that—

during the 1928 and 1932 half decade, 142 rural Michigan townships developed property tax delinquencies which varied in amounts from 5 to 10 percent of tax levies at the earlier date and from 30 to 35 percent at the later date, the total increase, furthermore, in numbers of delinquencies during this period being from 9,682 to 25,026. Farm tax sales also nearly doubled during the same period, increasing from a total of 1,862 at the earlier date to a total of 3,439 in 1932; this, despite lowered assessed valuations, tax levies, tax rates, and public budg-

ets. Back tax payments during this period declined from 52 percent of the delinquencies of 1928 to 26 percent of the delinquencies of 1931, but rather erratically rose again in 1932 to 39 percent. Tax sale penalty enforcement during this period in the same townships degenerated into wholesale defaults of tax titles to the State in the form of "tax bids", 70 percent of the sales going this way in 1928 and 91 percent in 1932. The lands sold at tax sales increased alarmingly also in the better farming counties of the State, these showing an average increase of 64 percent during the half decade.

The tax-sale penalty on tax-delinquent lands was found to be rather rigidly enforced in Michigan. No widespread laxity of penalty enforcement was found in this study.

Relief measures in respect to delinquencies attempted in Michigan have been through reductions of the tax levy, of the tax rate, and of assessed valuations, the remission of penalties, the deferring of dates of tax sales, and through amortizing the delinquencies over a 10-year period. Some evidence tends to show that suspension of penalties while giving relief from current taxes, is the direct cause of increased delinquency through the uncertainty developed as to tax collections.

The New Mexico Station finds that—

In 10 of the 31 counties in the State 2,364,619 acres of rural real estate were delinquent on the 1932 levy. This figure represented an increase of 121 percent over the 1,068,418 acres delinquent on the 1928 levy. The area delinquent on the 1932 levy was 28 percent of the assessed acreage of rural real estate in these counties. * * * The rising volume of rural real estate tax delinquency in the State from 1928 to 1932 was largely a result of heavy losses in farm income and in the purchasing power of farm products over this period. Cash income from farm production in New Mexico declined from $59,000,000 in 1928 to but $21,000,000 in 1932, a decrease of 64 percent. * * * The relatively high rate of both current delinquency and long-term delinquency in the self-sufficing irrigation farming and range livestock area was associated with the size of the farm units, with a low plane of efficiency in production, and with development of a seeped condition of much of the farming land resulting in some abandonment and lowered productivity. The comparatively low rate of both current and long-term delinquency in the counties of the extensive dry-farming and range livestock area was associated with relatively large farming units and with an upward trend in the efficiency of agricultural production.

Tax delinquency was greater in 1932 on rural real estate than on other kinds of property and was somewhat greater on farming land than on grazing land.

Tax laws relating to delinquency in New Mexico, as in certain other States, have not been fully enforced. The data for four counties show that for the period 1928 to 1932 tax certificates were sold against only 7 percent of the delinquent acreage.

There appears to have been "some decrease in assessed values of rural real estate over the period 1928 to 1932 which has helped to lessen the tax load on this class of property owners."

SOCIAL CONDITIONS

A social study of a college community.—The Virginia Station has made a somewhat detailed study of a college town surrounded and infiltrated to some extent with a considerable population of unprogressive people. It found that "practically half of the people of the area are of the marginal to submarginal type, far too many for community well-being."

Low income, poor housing conditions, and inadequate medical attention and educational and recreational facilities are cited as causes of the unsatisfactory conditions among the submarginal popu-

lation. Various suggestions regarding improvement of conditions are made, but

apparently the chief obstacles to their being carried into effect are nonrealization of the costliness of social drift, lack of a general appreciation of the value of given lines of action, lack of sufficiently aggressive leadership, inertia, and the difficulty of overcoming opposition to change.

On the other hand, many families of notably superior stock, as well as the college, have been influential in elevating community standards and ideals.

Economic status of sharecroppers.—Facts obtained by the Alabama Station from two counties of the State

indicate that the sharecroppers interviewed had opportunities in a business way essentially equal to those of other tenure groups under 1934 conditions in the area studied. This area is typical in both soil and topography of the Piedmont section of Alabama.

The population of cut-over lands.—A survey by the Louisiana Station of 862 households in a cut-over area in Louisiana, where lumbering operations are being discontinued because of exhaustion of timber resources, showed—

a dearth of young adults, a very perceptible population growth, a high degree of residential stability, limited educational training, and dependence upon a vanishing industry; all of these in combination suggest the problems which must be met if persons from this area are to be resettled.

Rural library service.—In a study reported by the Missouri Station it was found that only 44 counties out of 115 of the State had tax-supported public libraries within their boundaries, while an additional 43 contained nontax-supported libraries. A total of 28 counties had no public libraries. It further found that there are 1,740,897 people, or 48 percent of the State population, who are not served by public libraries. This group is comprised almost entirely of rural people.

Moving of farmers.—The South Carolina Station found that Negro tenants move less than white tenants. Owner farmers move on the average about every 8 years, while tenant farmers move every 3 or 4 years. However, among owner farmers the majority of the moving is done in early life, while among tenants moving tends to be continuous throughout life. Ownership of a farm seems to give stability, while tenancy appears to furnish little incentive to stability. It was found that 84.4 percent of the moves were made in the county in which the farmers lived at the time the survey was conducted (1933). This indicates that, while farmers do a great deal of moving, most of it is done within the home county.

Farmers who have moved the most have met with the least success. It would seem that there is great need for a contract between the tenant and his landowner that will give greater stability to the former and that will also improve the working relations between the two. The station concluded that it is almost certain that poor working conditions for tenant farmers such as now widely prevail are disastrous to both tenant and landowner.

Part-time farming.—In a study of part-time farming in Connecticut, the Connecticut (Storrs) Station found that of the approximately 80,000 persons engaged in agriculture in Connecticut, 60 percent are part-time farmers. The 32,000 persons, or approximately

2 percent of the total population of the State who live by the land alone, produce 97 percent of the total agricultural products of the State valued at more than $40,000,000. These products are grown largely for the local markets, in which there is an increasing demand for them. All of the farms studied are within commuting distance of 70 factories within the localities included in the study and three large cities nearby. It was concluded that further development of a part-time farming program could make considerable progress toward improving social conditions in the area.

The Delaware Station found that part-time farming is not highly profitable in Delaware and that the operation of such a farm is attended with much work and some inconvenience, but that most of the occupants find the balance to be in favor of part-time farming as contrasted with living in the city. The station advises those who contemplate part-time farming to be sure they have sufficient money income from other than part-time farming to enable them to provide a means of transportation, to afford the necessary household conveniences, and to retire a reasonable proportion of their indebtedness each year. The station points out that part-time farming requires good health and a willingness to do hard work and to forego many momentary pleasures. Moreover, it should be realized that profitable speculation in real estate is exceedingly rare.

"Part-time farming", says the Iowa Station, "is becoming a big business in Iowa and this combination of rural living, farming, and industrial employment may influence appreciably the future development of the State." The station concludes that—

> part-time farming contributes to greater security through home ownership which may be further encouraged by adequate financing. * * * Income from part-time farming can be increased in some cases by specialization but much more frequently by producing a greater variety of products for home consumption.

Part-time farming, to be successful, must be done in a more businesslike manner than is now the case, since it is obvious that increased production alone will not succeed if farming is poorly done and community institutions such as schools and churches, and modern conveniences are lacking.

Investigations by the Indiana Station indicated that part-time farming has increased the taxable wealth of many communities in that State which had suffered a decline in farming population and a diminished amount of taxable property. The station concluded that part-time farming affords a certain economic stability of the wage earner and in many instances enables him to provide better food and living conditions for his family than he could otherwise. It states that under present conditions part-time farmers do not seriously compete with full-time farmers since part-time farmers produce in small quantities and sell only a very small part of what they produce. The station advises that—

> The average part-time farmer should have reasonable assurance of at least 120 days of gainful employment yearly away from the farm, or he must have a volume of farm business large enough so that the sale of farm products is a major source of cash income if a satisfactory income is to be provided for the family.

Usually it is more practical to produce a greater variety of products for home use than to attempt commercial production.

Studies of experiences of operators of small farms, mostly near towns, by the Kentucky Station, indicated that many persons who undertake part-time farming with the hope of financial gain are likely to be disappointed. The production of food for home use and the enjoyment of country life were the chief advantages gained by living on a part-time farm. The total income of 329 part-time farmers whose experience was studied by the station

averaged $1,311, of which $877, or 67 percent, was received from work done off the farm. Farm receipts comprised 6 percent, food furnished from the farm 11 percent, and the rental value of the dwelling 15 percent of the total income. After expenses, including unpaid family labor and interest on investment, were deducted, the average part-time farmer earned $34 from his farm. These farm earnings plus income from other sources resulted in total labor earnings averaging $933 per farm operator. * * * The advantages of part-time farming apparently were due to decreased food and living costs rather than increased cash earnings. The security offered during periods of unemployment is an important factor which attracts persons engaged in seasonal industries or whose positions are insecure.

Contrary to popular opinion that part-time farming appeals to large-sized families, one-third of the farmers whose operations were studied were young people with few children or retired couples whose children had left home. The station suggests that "in most cases part-time farming should not be undertaken unless the entire family likes country life and is agreeable to the enterprise."

"Part-time farming in Oregon", says the Oregon Station, "is an established fact and not an experiment. More than 25 percent of the farmers of Oregon are considered as part-time farmers in that their farms are too small to produce a living." The chief advantages of part-time farming the station considers to be country life and lower cost of living; the chief disadvantages, distance from city, work, or school, and lack of employment; the chief mistakes, paying too much for the farm or buying too small a tract. The station found 94 percent of the part-time farmers to be satisfied, 2 percent undecided, and 4 percent dissatisfied.

In a study of part-time farming, the Washington Station found that it afforded the farm operator an opportunity to conserve his resources and lower his cost of living while working at some occupation not connected with the farm and that this type of farming has grown greatly in importance during the past few years. Such farms are located mainly within or adjacent to urban and industrial centers. Nearly three-fourths of them are situated west of the Cascade Mountains and in 1933 the most common size was 2 acres, with from one-half to 1 acre in crops. The value of land and buildings averaged $2,771 for the entire State, the most usual value ranging between $2,300 and $2,500, while the value of the dwellings was most frequently within the range of $500 to $2,100. Thirty percent of the farms reported no sales, 53 percent sales ranging from $1 to $199, and 17 percent sales amounting to $200 or more. Expenses of production averaged $131 per farm, or 45 percent of the average value of farm production.

B. Youngblood.

AGRICULTURAL ENGINEERING

Engineering is an important essential to the success of practically all farm and home operations. A few of the more significant examples of recent station work and accomplishments in agricultural

engineering are recorded here to illustrate its broader economic aspects and to indicate the character and scope of service rendered by the experiment stations through coordination of engineering research with that in commodity production and home enterprises.

Rubber-tired tractors.—The power required for traction operations on farms represents from 25 to 40 percent of the cost of production of crops. Some 13 of the stations have continued to study and develop the use of low-pressure pneumatic tires for tractors with the idea of increasing the working capacity and reducing the expense of labor and fuel. Typical of the results of this work were those secured at the Ohio Station, where it has been found that a tractor equipped with low-pressure pneumatic tires has a lower rolling resistance than one equipped with steel wheels and lugs. The Illinois Station found that rubber tires increase the drawbar pulling capacity of a tractor enough to allow the tractor implements to be pulled in high gear. It appears that the fuel consumption of a tractor equipped with rubber tires will usually be less than that of a tractor equipped with steel wheels and lugs at the same relative drawbar pull. It also has been found that under most conditions rubber tires on tractors are satisfactory equipment when the tractor is used for plowing and most other farm operations, and that, under favorable conditions, the rubber-tired equipment will transmit a greater drawbar horsepower than steel equipment in second or third gear.

Rubber tires make it possible to use the tractor for many more purposes than when steel-wheel equipment is used and permit higher speeds, but generally result in greater fuel economy. The Indiana Station showed, for example, that when pulling a three 14-inch-bottom plow the rubber-tired tractor gave a fuel saving of 11.8 percent and increased the speed of operation 0.12 mile per hour over the steel-wheeled equipment. Seedbed preparation with an 8-foot tandem disk and a 10-foot spike-tooth harrow was accomplished at a fuel saving of 6.4 percent and a speed increase of 0.41 mile per hour, and a second time over operation with the same equipment at a fuel saving of 15.8 percent and a speed increase of 0.25 mile per hour. A dual pneumatic-tire attachment, for use on a tractor when cultivating listed corn, has been developed by the Iowa Station. This is adapted to use on any cultivating-type tractor having adjustable wheel spacing. The attachment consists of a standard rim welded to a 12-inch spacing band which is clamped to the spokes of the regular wheel. This makes the tire centers about 15 inches apart. The dual attachment is used only on one side of the tractor and is set up straddle the ridge. The tire on the opposite side is centered on the ridge. With this equipment there is no trouble with slipping off the ridges unless the front wheels get off. These can be forced back by using the brakes, and, with the tire equipment described, the rear wheels will climb back on the ridges quickly.

Rubber tires for farm machinery.—In view of the large investment in power-drawn and -operated equipment on farms and the necessity for economy in their use, combined with the importance of timeliness in the cultural and harvesting treatment of crops, several of the stations have continued studies of the use of rubber tires on farm machinery. The draft of farm machinery is usually very high, owing to the fact that such machines are drawn largely over rough soil

which frequently is in a loose condition. Typical of this work is that in progress at the Ohio Station, where it has been found that on all rough and soft tractive surfaces, wagons equipped with low-pressure rubber tires require the least draft. On cultivated soil or meadow, the rubber tire on farm machines does not cut in as deeply as the rims of steel wheels, and thus the damage to the land is not so great. The second advantage of rubber tires on farm machinery is the fact that speeds can be increased. It was found that on a cinder road the least draft was recorded at a speed of approximately 8 miles per hour for wagons equipped with rubber tires. The usefulness of rubber tires for heavy field equipment has been indicated by the finding that a corn picker equipped with rubber tires required much less draft than the same picker equipped with steel wheels. The Indiana Station demonstrated that a rubber-tired, power-driven manure spreader was able to haul and spread manure whenever the ground could be traveled over without damage to the soil, and hauled and spread approximately four times as much manure in a day as did one man and a team.

Power feed grinders.—It has become evident during recent years that animal nutrition may be aided materially by grinding feeds to certain degrees of fineness corresponding to the needs of particular types and breeds of animals. Several of the stations, including especially those in Pennsylvania, Ohio, Nebraska, Kansas, Indiana, Idaho, Washington, and Wisconsin, have determined the limits of fineness between which grinding of feeds pays on the farm for various kinds of livestock, and fineness moduli have been established for these purposes. The necessity for economy in feed grinding has indicated the desirability of adapting the smaller sizes of grinding mills, such as the 5-horsepower unit and smaller, for this purpose where possible. In efforts to accomplish this the Wisconsin Station has demonstrated that in order to obtain high grinding efficiency in the small burr-type mills the speed must be high and the mill must be equipped with a feeding device which will continue to feed the mill uniformly at any desired rate. The permissible rate of feeding of such a mill was found to be almost directly proportional to the speed. It was demonstrated that the small-size burr mill performed as well as the hammer mill, and with greater safety, and that if the burr mill is operated at fairly constant speed and rate of feeding it will grind to a nearly uniform fineness for a long period at a given burr clearance. It was found, however, that the operation of small-size mills at high speeds necessitates the use of rigid burr mountings, antifriction bearings, and fixed burr clearances, as well as safety release devices, to prolong the life of the burrs and the mill. To meet these requirements the station developed the design of a small mill which embodies all the features found desirable in the studies of efficiency and performance and which can be manufactured commercially on a mass-production basis. (See also p. 104.)

Mechanical harvesting of cotton.—For more than 300 years the cotton crop has been harvested in this country by hand. As cotton culture has spread into areas where few laborers are required to produce large crops, and help for a timely harvest is sometimes hard to secure, many farmers, rather than lose much of the crop produced, have begun to use home-made mechanical devices, such as sleds, to

harvest as much of the crop as possible. On account of their apparent success in areas such as western Texas, interest in mechanical devices for harvesting cotton has gradually spread to all sections of the Cotton Belt. In view of this, the problem has been studied by the Texas Station not only from the standpoint of mechanical devices but also from that of the suitability of existing cotton varieties to mechanical harvesting. In recent tests of a roll-type stripper sled, using different kinds and sizes of stripping rolls operated at different angles and speeds, the station found that stripping rolls made of steel and wood having a slightly roughened surface gave high efficiency in harvesting cotton. Rolls 56 inches in length, operated at an angle between 25° and 30° with the ground and having a peripheral travel faster than that of the forward travel of the tractor, were the most efficient of the different combinations of roll angles and speeds. Stripping rolls $2\frac{3}{16}$ inches in diameter were more satisfactory than rolls 3 inches in diameter. In tests of the so-called Texas Station harvester the highest percentage of cotton was harvested when a high roll speed was used. Wood and steel rolls were not as efficient in harvesting as rubber rolls and knurled steel rolls. In cleaning mechanically harvested cotton, the Texas Station bur extractor and the Texas Station cylinder cleaner successfully removed foreign material, consisting of burs, green bolls, dirt, and trash, amounting to approximately 50 percent of the weight of the harvested cotton. Cotton thus cleaned classed higher than when otherwise extracted and cleaned. The highest efficiency of the Texas Station harvester was obtained with cotton varieties having short fruiting and vegetative branches and storm-resistant bolls. The station has been successful in developing high-yielding strains of cotton especially adapted to mechanical harvesting.

Erosion-control methods and equipment.—The development of erosion-control measures, prominent among which are those of a mechanical character, has been undertaken by practically all of the stations. Much of this work has been done in cooperation with the Soil Conservation Service of this Department. Economy in such measures as well as efficiency and permanence is an important essential. In that connection and typical of the station work was the development by the Missouri Station of the principles of an elevating grader type of terracing machine that reduces the power, labor, and time requirements for terracing by 50 percent on each item. That station also developed a low-cost dam which has proved an efficient means for the control of gully erosion. This structure consists of a tamped core of earth across the gully to the desired height, plastered with a 2- to 4-inch covering of reinforced concrete. The control of erosion in terrace outlets also was satisfactorily accomplished by the development of low-cost outlet structures made of rubble masonry laid up in concrete mortar and plastered. Mangum terraces and brush and woven-wire dams developed by the Indiana Station effectively checked gullying in pasture land even during periods of unusually heavy rainfall. The Iowa Station showed that variation in equipment used in building terraces usually constitutes the major factor influencing cost. In an experimental terracing program carried out on 145 farms in 18 southern Iowa counties, it was found that where teams, slip scrapers, and plows were used or where

teams and V-drags were used, the total cost of terracing per mile was considerably over $100 and per acre protected over $4. In contrast to this, where tractors and specially developed terracing graders were used, the total cost of terracing per mile ranged between a little over $16 and about $33 and the cost per acre protected between $0.88 and $1.79.

The essential technical features of terraces have been established by the Minnesota Station, it being demonstrated that under soil conditions similar to those prevailing in Minnesota no part of a terrace grade should exceed 0.4 foot in 100 feet and the total length of a terrace should never exceed 2,000 feet. None of the terrace slopes should ever be steeper than 1 foot vertical rise to 4 feet horizontal run, and reduction of the grade of gully floor to 2 feet or less per hundred feet by use of check dams is essential. To meet the last requirement methods of check-dam construction specially adapted to heavily manured corn soils which reduced gully slopes to approximately 2 percent were developed by the Missouri Station. As regards the net income from the terracing of farm land, the Oklahoma Panhandle Station showed that level terraced land yielded 31.08 bushels more of grain per acre than adjacent unterraced land over a period of 10 years, or an average of 3.1 bushels annually. Terraces placed about 35 feet apart on land with 1-percent slope were the most efficient from the crop-production standpoint, being nearly three times as efficient as 70- and 140-foot spacing. The average annual net cash income from terracing over the 10-year period was estimated at $1.75 per acre.

Wind-erosion prevention.—Soil blowing in portions of the central and southwestern Great Plains States has been and probably always will be a serious erosion problem. Modifications in cropping practices to cope with the situation have been developed by several of the stations in the region with due regard for adaptability to climate and soil and with a constant vegetative cover on the land as the first consideration. Apparently the greatest danger from soil blowing occurs on fallow land generally seeded to winter wheat and on row-cropped land, especially if sandy. Factors that aid in the control of soil blowing are shallow tillage of a nature that produces clods and leaves the organic matter at the surface, and ridging the soil at right angles to the prevailing winds, according to the Colorado, Kansas, and Wyoming Stations. The Colorado Station has demonstrated that the fountainhead of any soil-blowing stream can be broken up by roughening the surface by means of furrowing implements, preferably of the lister type, that penetrate deeply enough to lift flocculent, cloddy soil to the surface. The choice between the lister and the more shallow-furrowing implements depends on the seriousness of the blow situation and whether the blowing field is seeded. The blow spot should be furrowed beginning on the windward side and the furrows should be spaced closely enough to break up the soil sweep. It was found that if the land is not seeded, listing will nearly always prepare hard land to resist any and all subsequent windstorms if clods are lifted to the surface.

Recognizing the seriousness of the wind-erosion situation, the State stations of Colorado, Kansas, Oklahoma, and Texas are cooperating with the Department in an erosion survey of approximately 24,900

square miles in the wind-eroded areas of those States. The purpose is to collect more complete information than is now available regarding conditions existing in the area upon which to base future soil-conservation and erosion-control operations.

Farm irrigation pumping plants.—The widespread nature and seriousness of the droughts of the last few years, coupled with preceding water shortages, have created a need for greater assurance of an adequate water supply for crops not only in the semiarid regions of the country where irrigation is a common practice but in the semihumid regions of the Great Plains where irrigation is usually a supplementary practice. The stations throughout these regions have investigated the feasibility of pumping for irrigation for many years, and progress has been made in the development of pumping equipment specifically adapted to numerous local conditions. The use of irrigation pumping plants thus has increased rapidly in recent years. For example, in Nebraska where irrigation for the most part merely supplements rainfall the total number of irrigation pumping plants is well over 1,000 and in Colorado over 1,100. Since pumping for irrigation appreciably increases the cost of crop production, the stations have been interested in economy in pumping as well as adaptability of the equipment to local conditions. Typical of the station investigations on irrigation pumping in those regions where irrigation is essential to crop production are those at the New Mexico Station which have resulted in the development of practical specifications for farm pumping plants adapted to New Mexico agriculture and which incorporate economy with serviceability. The station has found, for example, that for best economy farm pumping plants should be large enough only to provide an adequate supply of water for the area to be irrigated and that continuous operation of the plant tends to reduce the cost per unit volume of water.

Electric motors have been found by the New Mexico Station to be the most suitable power units for irrigation pumping so far as mechanical operation and care are concerned. Similar practical specifications for operation have been developed by the Washington Station, it having been found that the smaller sizes of centrifugal pumps are well adapted to farm irrigation and their cost and maintenance expenses are low. The suction pipe of such a pumping plant should be large, air traps and leaks in the suction pipe should be avoided, as well as long horizontal runs. Such plants may be operated successfully with electric motors, stationary gas engines, or tractors. The last is especially useful where pumping is done from several water sources requiring frequent movement of the equipment. Practical instructions on the construction of wells for irrigation pumping also have been issued recently by the Colorado Station. A box-type home-made centrifugal pump has been devised by the Montana Station which is thought to be well suited to pumping water for irrigation under conditions in Montana where low lifts, cheap water, and cheap and temporary equipment are required.

The Parshall flume.—Water is the most valuable of the essential assets of western irrigation agriculture. Large expenditures have been made in the irrigated farming districts in the development and installation of irrigation works and canal systems to furnish water to farms. These, with the cost of preparing large areas of land for

irrigation and the establishment of legal rights to the use of water, represent a vast irrigation investment. The need is thus emphasized for conservation of irrigation-water supplies of which correct measurement of amounts distributed and used on farms is an essential feature. The Parshall flume, developed by the Colorado Station cooperating with the Department of Agriculture (B. A. Eng.) for measuring irrigation water, has proved practical under field conditions which make a standard weir or rating flume impractical either because of silting troubles or insufficient grade. The accuracy of measurement with this device is entirely within practical limits, 89 percent of the free-flow tests having shown observed discharges within 3 percent of the computed amount, and 85 percent of the submerged flow tests an accuracy within 5 percent. The range of capacity of discharge from a minimum of less than 0.1 second-foot through the 3-inch flume to a maximum of 1,500 second-feet through the 40-foot flume is sufficient to meet ordinary requirements. The flume will withstand a high degree of submergence without affecting the rate of free-flow discharge and will operate successfully in sand- or silt-laden streams. The flume has no adjustable or moving parts, is easy to construct, and may be built of lumber, concrete, or sheet metal.

Snow surveying.—The method of snow surveying in mountainous sections to indicate potential irrigation-water resources, originated by the Nevada Station and further developed by the Utah Station, is finding wide application in this country and abroad. It is now being used in a Federal system of snow surveys organized by the Bureau of Agricultural Engineering of the Department in cooperation with experiment stations, water commissions, and other local agencies in several of the Western States.

Livestock buildings.—The need for low cost as well as efficiency and durability in farm structures used as livestock and poultry shelters and for production purposes has engaged the attention of a majority of the stations for some time. This has become particularly important during recent years where the difference between production costs and gross income from livestock and poultry has narrowed to a minimum. To meet this situation the stations have analyzed the various production structures used on farms in the light of production requirements in efforts to lower the cost of specific structural features by the use of improved structural methods and where possible of cheaper structural materials. For example, a low-cost loafing barn for dairy cows has been developed by the Missouri Station. This barn is built of pole-frame construction around a central hay storage to the ground and has sheet-metal sidings and roof. Ventilation is secured by use of a straw loft and the floor is of tamped clay or concrete. It is estimated that, for the purpose intended, this barn should have a serviceable life of 30 years. It is convenient and well balanced as to feed storage. It can be built in some localities for as little as $900 and renders the same service as other structures costing three or four times as much. Low-cost reinforced tile floors consisting of a combination of clay tile, concrete, and reinforcing steel have been adapted by the Iowa Station for farm buildings, especially those used for animal production where fireproofness and strength under varying loads are as essential as permanence and ease of construction. This type of construction was found to have decided

advantages in all these properties over other types of floors used in farm buildings. The cost also compares favorably with that of other floor types.

The use of a gravel-asphalt mixture for floors of farm buildings has been developed to the successful stage by the Michigan Station. This material, as adapted to farm-building use, has been found to be cheaper than other materials, is waterproof and warmer than concrete, and is easily kept clean. It is especially adaptable for floors in cow stables and poultry houses and for paving barnyards, but is not adaptable for stables where shod horses are kept. It possesses the special advantage over other materials for cold winter climates that it does not crack under the heaving action of frost.

Farm-building insulation.—Proper insulation has been found to be an essential feature in the construction of practically all types of farm buildings, including especially dwellings, animal- and poultry-production buildings, and certain types of crop storages. Since the purpose of insulation is to aid in temperature control, it becomes an important factor of economy in heat conservation in both artificially and naturally heated structures. Insulation thus is a significant item in the cost of farm-building construction which several of the stations in the colder portions of the country have studied in efforts to combine low cost with efficiency. Typical of this work was the study of the relative insulating values of such readily available native materials as sawdust, shavings, peat moss, and ground corncobs by the Michigan Station. All of these materials proved to possess high insulating values if they can be kept dry. Coarse shavings are better than sawdust for this purpose because they are usually more resistant to decay and do not settle rapidly. It was demonstrated that ordinary hydrated lime dry mixed with these insulating materials is the most practical preservative, as it retards microbial growth and keeps out rodents. About 2 pounds of lime to every 100 pounds of shavings, or about one-fourth pound of lime to a bushel of shavings, are suggested as the best mixtures.

The native insulating materials are not suggested by the station as a substitute for commercial insulation in all cases, but where they are available they have been found to offer a low-cost solution to the problem of insulating all types of farm buildings if properly used. Poultry laying houses that were insulated by means of a straw loft were found by the Missouri Station to be between 10° and 15° cooler during the hot months. Hens in such houses not only laid more eggs but larger eggs and reached their peak of production in February. A straw-loft poultry house has been designed by the Wyoming Station which has shown several advantages over other types of houses now in use in cold high-altitude climates like that in Wyoming. The air is properly circulated without undue loss of heat from the house, and the moisture, rising with the warm air from the hens, passes through the straw of the loft and on out of the house. The straw loft acts as an insulator, keeping the house warm in winter and cool in summer. Recent investigations by the Ohio Station confirm the conclusion that too many windows tend to counteract the beneficial effects of insulation in poultry houses. The New Jersey Station demonstrated that a brooder house with a white roof was at least 6° cooler than one with a black roof.

Termite control in farm buildings.—Injury to the timbers of farm structures by termites often results in the necessity for expensive repairs. In the aggregate this expense may assume considerable proportions when the number of farm buildings exposed to termite injury is considered in connection with the initial investment in such structures. Several of the stations have studied the biology and habits of the termite in connection with methods of construction which will contribute to their control. Typical of this work is that at the Connecticut (State) Station with the eastern termite, where practical methods of building construction have been developed which exclude these termites. Included in these methods are keeping the wood from contact with the ground, the use of lumber adequately treated with preservatives such as coal-tar creosote, the use of impenetrable concrete or masonry, and the use of a metal termite shield. The station has found that by these methods termite-resistant buildings can be erected and infested buildings can be altered to exclude the pests. Also cutting off termites from their source of moisture exterminates those already in a building.

Fuel briquettes from waste farm products.—The annual cost of heating farm homes, particularly in the northern half of the United States, is relatively high. It is higher than that of the average city house of the same size because of more exposed location and the necessity for hauling such fuels as coal and oil from urban shipping centers. To partially relieve this situation studies have been made by several of the stations to develop the efficient use of fibrous waste products of the farm such as straw, cornstalks, corncobs, shavings, sawdust, and hulls as a supplement to the more costly fuels now in common use. In that connection the Idaho Station found that most agricultural waste products when compressed under high pressure into the form of briquettes make satisfactory fuels, with heating values comparable to that of wood. The burning characteristics of wheat-straw briquettes more nearly approximated those of coal than did briquettes of wood waste, maintaining their original form a greater length of time. Boiler tests showed that wheat-straw briquettes gave the highest boiler efficiency of any of several fuels tested, including wood, pine wood briquettes, and coal. Suitable briquetting machines may be leased and located in centers where large amounts of waste farm materials are available. Through this means such materials can be transformed into useful supplementary fuels.

Use of electricity in agriculture.—Owing to the stimulation given recently by both public and private agencies to the extension of lines for the distribution of electricity to rural and farm areas not previously served, the stations have continued and expanded their efforts to develop and adapt electric equipment to farm requirements, including both production operations and household uses. Not only are the total number of farms served by electricity and the total amount of electricity used on farms gradually increasing, but new practical applications of electricity to agriculture have been developed and old uses have been improved along cost-saving lines.

Soil sterilization by electricity.—Where plants are grown intensively in the same soil year after year both in greenhouse ranges and large areas and in greenhouse ground beds, benches, hotbeds, flats, and pots, soil sterilization is becoming a common practice. Several

of the stations in States where greenhouse and truck production are major agricultural industries have successfully developed and adapted electrical methods and equipment to this practice. The New Jersey Station, for example, has successfully developed both the batch and resistance methods for the pasteurization of greenhouse soils of which the latter appears the most useful. The Ohio Station has developed the resistance-type soil sterilizer to the point where it presents the advantages of low first cost and operating cost, even temperature distribution, and simple construction. (See also p. 20). The New York (Cornell) Station has found the electric method of pasteurizing soil to be universally effective against all pests. Both the soil-resistance and heating-element electrical methods were found as capable of destroying a number of common pathogenes, including bacteria, sclerotial fungi and nematodes, and weed seeds as the best standard methods otherwise used. In the interests of economy as well as effectiveness, the station showed that it is not necessary to raise soil temperature above 70° C., in the presence of adequate moisture, to kill several common soil pathogenes, and all kinds of soils from pure sand to pure muck can be effectively treated. In general, a 50° rise in temperature from initial 20° to final 70° has required from 1 to 1.3 kilowatt-hours of electricity. Where only nematodes and damping-off organisms are being combated, lower final temperatures are effective, at a saving of electricity, if more time is used. Studies of the operating characteristics of the resistance-type soil sterilizer by the California Station demonstrated its simplicity, low cost, ease and speed of operation, uniform heating performance, and semiautomatic operation, but brought out the disadvantages of hazard from electrical shock and variable electrical load. The shock hazard was reduced by the use of lower voltages and the addition of an electrolyte to the soil to increase current flow, and the variable electrical load situation was improved by the use of variable voltages.

Electric hotbeds.—During the last 12 years development in the use of electric heat for hotbeds and coldframes largely by the State stations has resulted in the wide acceptance of this heating method by vegetable gardeners. More recently the stations have demonstrated the usefulness and economy of this method of heating for florists and nurserymen who have applied it to bench crops as efficient means for supplementing greenhouse heat and for controlling growth in restricted areas in the greenhouse. The principal uses are heating soil for the germination of seeds, propagation of cuttings, and forcing transplants. Nurserymen especially are obtaining better results in rooting cuttings in electrically heated beds than in manure or other type beds.

The station studies have shown that it is easier to maintain an optimum temperature and the labor and annual investment costs are reduced appreciably with electric hotbeds. It has been found desirable to keep the soil from 15° to 20° F. above air temperature, especially for evergreen and hardwood cuttings, and this can be accomplished efficiently with electric heat owing to its ease of control. According to the New Jersey Station electrically heated seedbeds are of special value in floriculture in that quicker high-percentage germination is obtained and bed temperatures may be controlled

independently of the regular greenhouse heating system. The California Station demonstrated that the actual requirement of electrical energy by propagating benches is likely to vary considerably for different operating conditions. From studies of this situation information was prepared for practical use indicating the connected electrical load necessary in propagating benches under different conditions. Ability to adjust the heat to plant requirements in electric hotbeds has resulted in economical operation according to the New Jersey Station. Heating units are easily and quickly installed at low cost for labor and equipment, whereas manure-, hot water-, and flue-heated beds require considerable labor and equipment. The station finds the total cost of electric hotbeds is less than that of manure hotbeds with manure at $6 per ton. Several of the stations have issued practical instructions for the construction of low-cost electric hotbeds. Typical of these are instructions issued by the Washington Station for a 6- by 6-foot hotbed, the cost of the electrical heating system for which is estimated at about $10.

Electric brooders.—Since the advent of electric brooding many types of electric brooders have been constructed. The conversion of electrical energy into heat in any electric brooder is a simple matter, but owing to the wide use of this equipment the stations found it necessary to further develop the principles of design of such brooders in order to utilize the heat effectively and economically. Typical of the efforts by the stations to accomplish this were those by the Pennsylvania Station where it was demonstrated that control of ventilation in brooders, insulation to prevent heat loss, thermostatic control of temperature, proper heat distribution, and the availability of sufficient wattage to meet all extremes of room temperature are essential to successful and economical operation of electric brooders. Electric brooders when properly constructed and operated can be used at about the same cost as coal brooders, according to the Michigan and New Hampshire Stations, both of which were unable to demonstrate any advantage of floor insulation in such brooders. It appears that there is no relationship between floor insulation and mortality. It was demonstrated by the Indiana Station over a period of 5 years' experimentation, however, that in properly operated electric brooders chick mortality could be brought as low as 3.2 percent, with an average energy consumption as low as 0.33 kilowatt-hour per chick.

Electric heat for laying hens.—The value of supplementary electric heat in laying houses has been demonstrated by the Idaho Station. In a comparison of a circulation-type electric heating device with the underground coal-fired furnace commonly used, it was found that heat was made available immediately by the electric heater when an automatic thermostat control was used. Forty-four kilowatt-hours were used during a 3-day cold period by this type heater, which was designed and built by the station. It was demonstrated that the chief advantages of the circulation-type electric heater for laying houses are that heat is automatically available and that operating costs are less than for the coal-fired furnace.

Precooling of milk.—The farm milk-cooling problem has assumed national interest and importance. The stations in general have demonstrated that immediate cooling of milk definitely contributes to prolonging its original quality and that the desirable temperature

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of precooling is around 40° to 45° F. Electric motor-driven milk coolers have been developed by several of the stations to meet these requirements with a minimum of handling to avoid outside contamination. Typical of these developments is that by the Pennsylvania Station of an electric milk cooler with pneumatic agitation. The station found that it requires about 1.5 kilowatt-hours of electricity to cool a 10-gallon can of milk from an initial temperature of 90° F. to the desired 45°. The milk was found to cool faster and more uniformly with agitation of the cooling water and a ratio of cooling water to milk of 1.65 was sufficient when an ice bank on the cooling coils is available to hold and maintain the temperature of the cooling water at 33°. Working with similar equipment the New Hampshire Station developed a satisfactory low-cost device for agitating the cooling water consisting of a ⅜-inch iron rod mounted vertically in the tank and having a straight-line sweep motion at its bottom point of about 18 inches. When operated by the compressor-unit motor at a rate of about 100 complete strokes per minute a uniform temperature was produced throughout the cooling water. Under conditions where electricity is not available the Pennsylvania Station demonstrated that with the dry-type cooler from 38.7 to 40 pounds of ice are required per can of milk per day. The dry-type cooler is more economical in operation than the wet-type for equal amounts of insulation, but the dry-type tank must be re-iced more frequently when used to full capacity.

Electric insect-pest control.—Fundamental studies by several of the stations, notably those in California, Indiana, New Jersey, and New York, on the reactions of insects to light of different wave lengths have resulted in the extensive revival of the practice of using light to attract insect pests so that they may be trapped and destroyed. These stations have indicated definite possibilities in the use of certain lamps under certain conditions as an aid in the control of specific insect pests. The California and New York State Stations, for example, have demonstrated that light traps when properly used influence the codling moth population and that the resulting reduction in number of moths is accompanied by a measurable decrease in the amount of fruit injury. The former station found a considerable reduction of worminess of apples under blue light. A consistently greater attraction for codling moths by lamps with clear bulbs than by the same lamps with inside frosted bulbs was demonstrated by the Indiana Station. Also more females were attracted. There was little difference in the preference for Mazda C and Mazda CX types, but lamps radiating blue-violet and ultraviolet energy were distinctly more attractive to the moths. The region of the spectrum which seems most attractive is that between 3,000 and 4,000 Ängstrom units. The station has shown that the best position for a light trap is in a tree that carries a full load of fruit, has a fairly broad top, and is located higher than or is taller than the other trees. The trap should be at least a foot below the topmost foliage and as near the center of the tree as possible. The Clear Lake gnat was found by the California Station to respond about equally in numbers caught to wave lengths of light of equal intensity ranging from 3,500 to 7,000 Ängstrom units without any apparent peaks of response. As the lights increased in intensity from 40 to 300 watts there was a proportional increase in the number of gnats attracted.

The California Station has demonstrated that fields of artichokes illuminated by midnight blue lights steadily decreased in worminess due to the artichoke plume moth. Similar results were obtained with grape leafhoppers using red and white lights, but good results were obtained with blue light and a much greater ratio of females to males was trapped. The stations in general have established the fact that insect pests frequently possess a high power of color selectivity.

Artificial light in the greenhouse.—The use of artificial light as a practical means of forcing valuable greenhouse crops, including flowers, has recently been the subject of considerable investigation by several of the stations, notably those in Ohio, Indiana, and New York. In general it has been demonstrated that additional light at night increases flower production and stem length of the flowers of many crops and decreases the time required to produce flowers. The most desirable quality of some kinds of flowers was produced in cooler temperatures with added electric light by the Indiana Station. Filtering out the heat rays of infrared produced stronger stems with clarkia and some other plants, without delaying flowering beyond lighted plants without the use of filters. Good-quality scabiosa was produced by delaying the lighting until a good root system was developed. Additional light should be applied in the greenhouse from 5 p. m. to 10 p. m. or from 2 a. m. to 7 a. m. during fall and winter according to the Ohio Station. Low-wattage lamps (25 to 40 watts) suspended 2 feet above individual benches and spaced 4 feet apart have been found sufficient for most plants responding to additional light. Higher wattage lamps are more advantageous where the entire greenhouse is illuminated. Dome reflectors are the most satisfactory, although aluminum pie tins of similar size and depth are almost as efficient and are much cheaper.

In studies of the effect of narrow ranges of wave lengths of radiant energy on the reproductive growth of long-day and short-day plants the New York (Cornell) Station demonstrated that red and blue lights are of approximately equal effectiveness in bringing about the reproductive growth response of radish, spinach, crepis, and *Marchantia*. Blue light is superior to red in causing flowering of lettuce. If natural light is supplemented during the winter months, especially with red or blue light, normal long-day plants such as radish and *Marchantia* can be forced into fruiting in a 10-hour day. At low light intensities the fruiting response of *Marchantia* is proportional to the increase of intensity.

See also page 81.

R. W. Trullinger.

STATISTICS OF EXPERIMENT STATIONS, 1936

By J. I. Schulte

The following tables give detailed data regarding personnel, publications, and mailing lists; income; expenditures from Hatch, Adams, Purnell, Bankhead-Jones, and supplementary funds; additions to equipment; and total disbursements from the United States Treasury under the Hatch, Adams, Purnell, and Bankhead-Jones Acts from their passage to the end of the fiscal year, June 30, 1936.

TABLE 3.—*Personnel, publications, and mailing lists of the experiment stations for the year ended June 30, 1936*

Station	Date of organization under Hatch Act	Number on staff	Teachers on staff	Staff members assisting in extension work	Publications						Names on mailing list
					Station publications		Articles in scientific journals		Miscellaneous publications		
					Number	Pages	Number	Pages	Number	Pages	
Alabama	Feb. 24, 1888	53	32	1	2	88	13	79	1	4	3,533
Alaska	July 1, 1931	2	2		1	51					467
Arizona	July 1, 1889	50	33	1	9	421	39	179			5,208
Arkansas	Apr. 2, 1888	48	38	4	14	562	16	16			5,500
California	March 1888	229	126		33	1,704	305	610	7	24	12,405
Colorado	Feb. 29, 1888	70	43	4	17	507	3	3			500
Connecticut:											
State	May 18, 1887	44			26	1,790	25	100			14,231
Storrs	do	33	13	6	9	312	13	26			11,000
Delaware	Feb. 21, 1888	24	9	8	7	268					9,000
Florida	March 1888	88	11	9	38	749	25	25	28	28	20,000
Georgia	July 1, 1889	34			7	132	6	21	13	153	7,000
Hawaii	July 1, 1929	23	9	3	4	214	5	47	8	66	1,264
Idaho	Feb. 26, 1892	52	32	6	4	86	14	109			20,575
Illinois	Mar. 21, 1888	120	75	10	11	788	207	917			27,500
Indiana	January 1888	108	30	5	15	414	96	428	12	50	39,320
Iowa	Feb. 17, 1888	145	74	13	35	1,720	80	500	2	228	26,055
Kansas	Feb. 8, 1888	107	80	1	9	362	104	104			12,000
Kentucky	April 1888	78	25	5	8	310	13	25	4	87	1,000
Louisiana	Apr. 5, 1887	59	10	3	14	345					1,310
Maine	Oct. 1, 1887	41	5		4	278	5	99	4	140	15,200
Maryland	April 1888	62	31	10	20	732					20,000
Massachusetts	Mar. 2, 1888	81	20		18	486	27	171	12	48	1,600
Michigan	Feb. 26, 1888	127	77	8	32	1,329	39	298	71	1,627	14,000
Minnesota	——1888	158	113	4	36	1,155	67	134	24	60	5,000
Mississippi	Jan. 27, 1888	56	20	3	5	95	3	3			5,000
Missouri	January 1888	78	60	3	33	1,022	54	54	52	364	6,175
Montana	July 1, 1893	45	16	7	25	587	23	23			5,000
Nebraska	June 13, 1887	62	42		15	253	17	17			5,000
Nevada	December 1887	20	1		3	77	6	71			4,500
New Hampshire	Aug. 4, 1887	54	29	9	8	193	1	6	3	40	8,000
New Jersey:											
College	Apr. 26, 1888	39	21		30	748	59	59			11,700
State		[1] 82									
New Mexico	Dec. 14, 1889	29	17		38	540	1	5			12,000

New York:											
Cornell	April 1888	147	115	9	27	1,321	231	1,595			49,453
State	do	74			27	754	57	114	4	46	15,000
North Carolina	Mar. 7, 1887	61	18	5	9	416	7	185			7,861
North Dakota	March 1890	55	28	4	8	296					13,000
Ohio	Apr. 2, 1888	125			29	1,217	69	69			33,086
Oklahoma	Oct. 27, 1890	66	45	1	61	356			2	195	6,703
Oregon	July 1888	99	41	6	12	373	12	80	30	150	1,800
Pennsylvania	June 30, 1887	142	142		42	772					30,000
Puerto Rico:											
Mayaguez		15									
Rio Piedras	Aug. 16, 1933	29			5	390	3	3	4	486	2,074
Rhode Island	July 30, 1888	32	18	5	11	221	5	17			4,000
South Carolina	January 1888	55	22	2	5	296	3	15			6,000
South Dakota	Mar. 13, 1887	42	32	4	9	380	16	16			23,250
Tennessee	Aug. 4, 1887	40	9		11	234	7	41			19,289
Texas	Apr. 3, 1889	121	1	1	14	744	22	240			78,181
Utah	Nov. 16, 1889	41	29	7	16	418	38	297	1	46	8,000
Vermont	Feb. 28, 1888	31	12	1	13	363	14	60			4,000
Virginia	March 1888	58	19	6	6	294	14	46	26	68	12,000
Washington	May 22, 1891	63	31		39	584	37	37	8	10	1,750
West Virginia	June 11, 1888	49	27	10	10	252	15	164			12,000
Wisconsin	July 1, 1887	149	103	43	9	409	161	322			62,000
Wyoming	Mar. 1, 1891	37	21	1	12	350	9	50	15	30	8,000
Total		3,818	1,807	228	905	28,758	1,986	7,480	331	3,950	728,490

[1] Including 14 who are on college staff but not included in total.

TABLE 4.—*Experiment station income for the year ended June 30, 1936*

Station	Federal grants				Supplementary						Total
	Hatch fund	Adams fund	Purnell fund	Bankhead-Jones fund	Balance from previous year	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	
Alabama	$15,000	$15,000	$60,000	$20,673.78	$64,933.07	$158,118.10	$3,450.00		$43,657.37		$380,832.32
Alaska	15,000			559.12	729.03	4,000.00			3,904.47		24,192.62
Arizona	15,000	15,000	60,000	3,105.64	2,947.08	92,686.25			4,665.09		193,404.06
Arkansas	15,000	15,000	60,000	15,995.80		60,148.72	3,457.78		17,920.21		187,522.51
California	15,000	15,000	60,000	16,485.49	18,585.89	798,329.70	64,630.92		45,221.11		1,033,253.11
Colorado	15,000	15,000	60,000	5,607.74	37,679.80	95,883.51		$47,500.33			276,671.38
Connecticut:											
State	7,500	7,500	30,000	2,582.26		206,230.90	5,335.00	23,500.00			282,648.16
Storrs	7,500	7,500	30,000	2,582.26		37,346.72		5,568.24	1,404.07		91,901.29
Delaware	15,000	15,000	60,000	1,252.55	4,757.88	20,767.71			15,255.67		132,033.81
Florida	15,000	15,000	60,000	7,700.41	20,924.06	377,208.70			25,198.08		521,031.25
Georgia	15,000	15,000	60,000	21,880.73	6,211.03	8,206.67			20,420.97	$4,954.67	151,674.07
Hawaii	15,000	15,000		2,296.60				14,455.17		[1] 55,314.23	102,066.00
Idaho	15,000	15,000	60,000	3,429.64	820.08	33,309.38		2,643.67			130,202.77
Illinois	15,000	15,000	60,000	21,684.13		353,604.03	12,714.46		50,738.86		528,741.48
Indiana	15,000	15,000	60,000	15,680.65	240,162.26	225,000.00	70,480.21	152,188.17	97,301.41	32,600.02	923,412.72
Iowa	15,000	15,000	60,000	16,213.66	12,246.86	200,745.58			52,682.57		371,888.67
Kansas	15,000	15,000	60,000	12,512.74	19,802.98	114,450.00		56,124.61		1,889.00	294,779.33
Kentucky	15,000	15,000	60,000	19,734.51	2,320.55	104,499.42		139,764.94	48,380.63		404,700.05
Louisiana	15,000	15,000	60,000	13,783.36	8,150.01	57,643.86	3,368.00	27,746.96	10,601.04	10,366.71	221,659.94
Maine	15,000	15,000	60,000	5,173.04		31,489.00		14,940.12	8,831.74	1,098.93	151,532.83
Maryland	15,000	15,000	60,000	7,137.62	22,808.78	43,141.54	16,647.25		25,221.68	4,406.06	209,362.93
Massachusetts	15,000	15,000	60,000	4,545.55		180,843.18	7,612.32	62,113.58	7,404.32	913.56	353,432.51
Michigan	15,000	15,000	60,000	16,741.96		243,055.84			23,008.73		372,806.53
Minnesota	15,000	15,000	60,000	14,199.41		382,112.26	5,987.00	719.05	40,787.98	673.48	534,479.18
Mississippi	15,000	15,000	60,000	18,162.85	22,004.84	65,000.04			74,189.50		269,357.23
Missouri	15,000	15,000	60,000	19,241.95	33,956.25	38,810.10	11,931.91	29,834.42	42,236.66		266,011.29
Montana	15,000	15,000	60,000	3,875.79	8,977.15	72,344.83			54,257.22		229,454.99
Nebraska	15,000	15,000	60,000	9,694.15		120,340.20			64,574.35		284,608.70
Nevada	15,000	15,000	60,000	615.16	3,506.61	4,308.16			5,542.30		103,972.23
New Hamsphire	15,000	15,000	60,000	2,089.30	25,930.04	3,584.20			3,238.09	25,462.27	150,303.90
New Jersey:											
College	15,000	15,000	60,000	7,631.46							97,631.46
State						455,192.50					455,192.50
New Mexico	15,000	15,000	60,000	3,440.25	39,839.64	2,984.99			11,593.00		147,857.88

New York:											
Cornell	13,500	13,500	54,000	20,212.12		550,914.49		17,972.23	53,916.68	2,403.96	726,419.48
State	1,500	1,500	6,000	2,245.79	2,139.87	361,331.29			13,585.34	17.00	388,319.29
North Carolina	15,000	15,000	60,000	25,657.00	3,060.55	123,272.29	2,460.00		15,514.41	456.41	260,420.66
North Dakota	15,000	15,000	60,000	6,168.94	2,977.09	59,759.00	250.00	290.00	36,118.95	3,051.95	198,615.93
Ohio	15,000	15,000	60,000	23,253.69	381,989.59	333,062.16			92,604.74	7,559.43	928,469.61
Oklahoma	15,000	15,000	60,000	17,112.71	14,804.21	51,593.91		46,074.12	30,141.70		249,726.65
Oregon	15,000	15,000	60,000	5,043.95	36,006.22	113,882.98	8,180.09	15,076.88	56,696.17		324,886.29
Pennsylvania	15,000	15,000	60,000	33,672.38	3,495.86	100,467.09			37,857.55	14,019.07	279,511.95
Puerto Rico:											
Mayaguez										[2] 37,245.00	37,245.00
Rio Piedras	15,000	15,000		12,138.04		121,355.00					163,493.04
Rhode Island	15,000	15,000	60,000	565.96	1,015.41				7,383.51		98,964.88
South Carolina	15,000	15,000	60,000	14,866.24	12,632.41	63,645.22			81,729.96		262,873.83
South Dakota	15,000	15,000	60,000	6,108.11	11,081.30	16,560.00	2,574.24	7,178.10	8,305.01		141,806.76
Tennessee	15,000	15,000	60,000	18,695.97		19,542.08			18,736.14		146,974.19
Texas	15,000	15,000	60,000	37,341.19	76,724.58	282,605.00			117,641.16	134,790.08	739,102.01
Utah	15,000	15,000	60,000	2,625.92	9,848.45	29,250.00	725.00		14,060.03	2,627.52	149,136.92
Vermont	15,000	15,000	60,000	2,617.90	711.12			23,030.59	491.66		116,851.27
Virginia	15,000	15,000	60,000	17,786.14	2,194.71	80,275.00			10,494.83		200,750.68
Washington	15,000	15,000	60,000	7,378.93		72,503.71	2,714.48		41,042.47		213,639.59
West Virginia	15,000	15,000	60,000	13,453.36	6,318.88	35,201.02	1,712.50		44,394.20		191,079.96
Wisconsin	15,000	15,000	60,000	15,056.22		233,834.89	67,366.26		106,036.19		512,293.56
Wyoming	15,000	15,000	60,000	1,689.88	61,030.65	41,618.33			21,949.60		216,288.46
Total	765,000	750,000	2,880,000	600,000.00	1,223,324.79	7,282,059.55	291,597.42	686,721.18	1,606,937.42	339,849.35	16,425,489.71

[1] Including $32,066 direct appropriation to the U. S. Department of Agriculture.
[2] Direct appropriation to the U. S. Department of Agriculture.

TABLE 5.—*Expenditures from Federal appropriations received under*

Station	Amount of appropriation	Expenditures							
		Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$15,000	$12,440.60	$1,144.51	$5.00	$152.37	$109.42	$121.15	$40.76	$299.94
Alaska	15,000	6,293.04	3,945.70	185.33	221.18	150.27	622.19	69.36	385.97
Arizona	15,000	14,999.04			.96				
Arkansas	15,000	7,086.82	2,610.35	1,306.24	131.35	111.27	61.98	432.44	520.25
California	15,000	15,000.00							
Colorado	15,000	14,863.70							
Connecticut:									
State	7,500	7,500.00							
Storrs	7,500	6,780.01			9.13				24.26
Delaware	15,000	8,551.01	1,749.98	621.28	1,209.61	18.31	367.10	360.20	103.73
Florida	15,000	15,000.00							
Georgia	15,000	8,745.00	2,008.58	663.26	839.82	21.58	296.62	87.82	240.29
Hawaii	15,000	5,712.78	3,856.86	879.86	57.33	17.34		530.57	382.95
Idaho	15,000	8,448.57	4,098.58	323.86	478.75	55.06	124.58	51.06	172.37
Illinois [1]	15,000	13,347.70	620.18						
Indiana	15,000	14,708.30	291.70						
Iowa	15,000	14,785.37			3.33				
Kansas	15,000	9,700.00	4,630.45	15.31	66.23			159.52	66.36
Kentucky	15,000	14,353.52	43.00	218.50	4.32			23.68	
Louisiana	15,000	8,755.00	4,208.69	1,123.46	133.76		21.49	23.25	157.90
Maine	15,000	7,491.72	1,014.59	38.11	599.91	110.70	1,358.07	142.80	389.11
Maryland	15,000	12,740.49	1,499.90	569.81	22.36			116.37	
Massachusetts	15,000	14,542.24							
Michigan	15,000	15,000.00							
Minnesota	15,000	13,815.65	100.00	134.16		1.60		16.90	226.32
Mississippi	15,000	7,082.52	3,317.84	31.50	320.85	121.73	399.87	26.00	605.88
Missouri	15,000	6,804.22	3,730.55	1,063.88	364.80	90.19	58.36	337.55	117.39
Montana	15,000	7,583.65	2,502.19	1,733.71	1,272.70	48.32	10.59	138.58	207.27
Nebraska	15,000	15,000.00							
Nevada	15,000	9,011.25	1,491.68	74.57	857.45	13.51	435.36	13.04	502.31
New Hampshire	15,000	9,887.22	954.70	652.82	1,319.29	306.71	700.93	52.47	41.86
New Jersey	15,000	10,686.00	737.73		406.53		49.50	347.23	273.97
New Mexico	15,000	8,572.38	3,417.21	740.26	184.71	83.89	418.50	516.34	321.95
New York:									
Cornell	13,500	7,974.26	3,839.58		133.26			677.59	37.10
State	1,500	1,500.00							
North Carolina	15,000	11,682.92	496.53	565.72	346.28	68.85		148.27	134.36
North Dakota	15,000	10,408.65	3,812.09						
Ohio	15,000	9,435.86			8.85		949.67	1,145.39	564.88
Oklahoma	15,000	7,398.14	3,061.62	62.13	96.49	294.12	50.41	309.76	615.40
Oregon	15,000	7,655.63	4,948.88	529.58	389.31	7.79	132.28	198.86	74.68
Pennsylvania	15,000	12,028.00	1,898.18	879.63			13.96		12.28
Puerto Rico [2]	15,000	9,796.67	1,700.95	649.86	340.14	16.51			13.50
Rhode Island	15,000	8,404.56	3,647.80	422.00	307.92	30.92	325.43	186.36	259.52
South Carolina	15,000	8,232.85	2,208.89	589.50	925.36	52.75		166.08	205.37
South Dakota	15,000	8,071.88	2,263.51	1,893.76	196.13	5.90	1.92	309.38	229.86
Tennessee	15,000	10,002.00	2,954.07	426.51	684.19	10.85	25.00	35.19	154.79
Texas	15,000	14,122.50	290.00		.66				
Utah	15,000	8,368.43	2,936.60	112.77	92.80	66.79		190.31	339.53
Vermont	15,000	8,026.31	1,537.94	1,145.83	229.82	36.40	915.02	329.18	549.75
Virginia	15,000	8,522.20	4,531.25	98.80	78.34	53.28	86.80	19.88	326.40
Washington	15,000	10,475.61	1,760.83	1,037.11	192.35			18.86	64.90
West Virginia [3]	15,000	4,929.97	3,556.85	1,064.83	123.93	311.96	692.13	448.54	406.24
Wisconsin	15,000	14,049.98	146.00	270.00	.25			21.35	
Wyoming	15,000	6,454.50	4,291.81	803.50	816.42	58.89	529.68	209.64	425.83
Total	765,000	532,828.72	97,858.35	20,932.45	13,619.24	2,274.91	8,768.59	7,900.58	9,454.47

[1] Including balance of appropriation from previous year, $271.68.
[2] Including balance of appropriation from previous year, $49.83.
[3] Including balance of appropriation from previous year, $0.29.

the act of Mar. 2, 1887 (Hatch Act), for the year ended June 30, 1936

Expenditures—Continued										
Fertilizers	Feeds	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Travel	Contingent	Buildings and land	Balance
$126.62		$398.26	$90.06		$5.00		$57.00	$9.31		
76.90	$3.15	46.25	488.93	$46.65	22.50	$1,624,12	123.60	9.75	$685.11	
245.55	1,640.12	7.86	54.61	63.55	117.02		209.79		400.80	
							136.30			
62.47					624.13					
105.28		821.43	45.68	573.80	230.55		238.29	3.75		
	298.54	100.75	136.54	209.41	22.75		1,113.29	8.95	206.80	
28.30	1,426.11	15.25	9.75	569.73	1,032.22	150.00	316.05	14.90		
	1.26		160.55	84.93	152.66		825.51	20.70	1.56	
										$1,032.12
				211.30						
41.16	12.00	2.35	14.36		36.65		255.61			
				42.72			289.26	25.00		
	5.70		230.64	2.00			338.11			
37.50	97.65	443.37	135.36	417.23	251.57	79.50	2,040.88	29.99	321.94	
							51.07			
							457.76			
25.55	171.53		67.41	141.66	5.00		250.13	44.09		
39.00	764.32	8.92	858.64	263.13			394.40	25.02	740.38	
67.81	1,041.50	46.75	326.36	209.44	176.76	250.00	274.64	.20	39.60	
	123.98	296.80	279.32	348.43	127.40	23.00	276.60	15.82	11.64	
	115.98	100.47	313.80	70.05	238.45	90.00	756.05	198.00	718.03	
56.30		500.27	28.91	74.17	5.22		416.85	2.28		
31.48	360.00	742.00	60.00	536.26	267.95		466.96	26.99	7.40	
87.74	9.60	3.05	193.11			100.00	158.82	99.26	93.18	
7.34		15.00		34.07	491.11	96.04	194.65			
84.64			35.20	179.40	71.16		1,148.17	32.50	6.00	
		1.00	60.10				718.16			
457.00	1,772.54		482.10	101.25	79.85		2.61			
49.50	806.40	4.20	882.56	108.83	393.98	461.00	402.08		3.38	
		5.00	135.97	130.00	60.45		716.67	14.90		
115.35							52.60			
		39.14	15.00	147.25	1,005.00		1,148.55			127.43
125.97	133.33	291.75	506.79	7.50	51.34		207.71	.50	90.25	.35
96.41	300.00	821.41	1,042.63	18.89	18.14		211.82	4.90	105.00	
	1,635.66		100.17	2.64	64.45		185.48		39.26	
2.50		191.44	373.31	37.61	3.25		79.99	4.80	14.50	
	5.00	20.40	78.75				473.33	9.36		
	1,834.59	74.35	324.12	8.00	37.00		588.50	4.92	21.29	
170.27		132.86	515.55	265.93	360.72		524.38	98.46	161.58	
81.11	1.00	21.75	56.32	19.75	105.05	400.00	598.07			
		59.11	2.75	5.09	436.00		947.39			
704.01	1,052.99		659.14		213.80		821.88	13.73		
				82.20			430.22			
	620.16		344.67	103.25			341.65			
2,925.76	14,233.11	5,211.19	9,109.16	5,116.12	6,707.13	3,273.66	19,240.88	718.08	3,667.70	1,159.90

TABLE 6.—*Expenditures from Federal appropriations received under*

Station	Amount of appropriation	Expenditures						
		Salaries	Labor	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$15,000	$11,524.02	$1,030.01	$49.46	$31.05	$309.50	$713.07	$328.69
Arizona	15,000	9,924.24	2,522.13	27.83	42.93		161.52	226.01
Arkansas	15,000	9,100.66	1,976.97	24.32	107.50	225.00	767.28	426.77
California	15,000	15,000.00						
Colorado	15,000	15,000.00						
Connecticut:								
State	7,500	7,500.00						
Storrs	7,500	7,500.00						
Delaware	15,000	11,208.00	1,441.49		9.94		1,015.22	67.44
Florida	15,000	15,000.00						
Georgia	15,000	7,950.41	2,415.83	6.86	107.87	598.85	685.31	78.25
Hawaii	15,000	10,901.73	1,865.00	8.13	24.85		971.72	34.35
Idaho	15,000	13,538.06	919.72	5.05	78.34	15.70	171.90	28.83
Illinois	15,000	11,238.88	3,761.12					
Indiana	15,000	12,462.00	843.38	3.78			434.96	153.64
Iowa	15,000	14,437.44						
Kansas	15,000	10,300.00	3,463.65	3.76	1.34	14.00	354.00	32.73
Kentucky	15,000	14,451.12	14.62		2.98	30.43	262.91	30.66
Louisiana	15,000	9,999.70	1,849.94	16.50	68.06	22.20	832.48	323.18
Maine	15,000	14,670.51			10.00	116.00	23.11	8.37
Maryland	15,000	13,497.76	216.00	57.61			327.61	16.66
Massachusetts	15,000	14,450.00						
Michigan	15,000	15,000.00						
Minnesota	15,000	15,000.00						
Mississippi	15,000	9,931.62	3,759.97	28.82	16.83	239.18	170.16	433.15
Missouri	15,000	3,444.81	5,243.35	30.93	120.31	102.63	1,927.03	412.45
Montana	15,000	10,010.85	2,210.50	11.32	1.39		653.08	62.26
Nebraska	15,000	15,000.00						
Nevada	15,000	11,775.73	1,893.57	116.87	18.54		221.46	83.06
New Hampshire	15,000	12,211.50	1,059.52	1.02	47.41		321.44	117.13
New Jersey	15,000	10,065.00	168.06	10.94		705.96	1,659.53	328.74
New Mexico	15,000	9,670.94	2,972.18	65.75	94.05	185.86	994.58	66.93
New York:								
Cornell	13,500	12,575.93	689.63	1.41			223.88	1.20
State	1,500	1,500.00						
North Carolina	15,000	11,139.50	734.84	15.00	15.19	14.92	448.82	43.94
North Dakota	15,000	13,348.25	532.65				35.57	11.42
Ohio	15,000	14,445.19		27.28			97.37	126.50
Oklahoma	15,000	8,715.85	2,130.73	6.60	9.45		1,003.81	196.67
Oregon	15,000	11,180.36	1,933.68	40.86	10.61		1,051.11	114.04
Pennsylvania	15,000	14,550.00	450.00					
Puerto Rico [1]	15,000	3,699.90	4,181.09	27.06	75.52		16.97	1,165.61
Rhode Island	15,000	11,599.10	1,567.06		10.45	85.87	11.55	14.85
South Carolina	15,000	8,804.65	2,094.80	143.50	44.34	173.11	786.55	131.48
South Dakota	15,000	8,120.57	3,714.53	40.03	64.39		383.78	75.59
Tennessee	15,000	13,175.30	679.30	10.28	16.12	36.13	242.45	94.65
Texas	15,000	14,517.50	465.00	1.66	13.85	1.99		
Utah	15,000	8,599.19	3,804.98	90.12	64.30		528.59	203.84
Vermont	15,000	9,607.93	3,365.86	83.87	22.61	22.92	419.20	305.88
Virginia	15,000	8,412.38	3,169.76	8.89		71.43	153.79	332.09
Washington	15,000	12,679.89	1,135.70	13.82			447.62	189.09
West Virginia	15,000	11,865.03	2,037.09		4.74	21.33	546.60	22.56
Wisconsin	15,000	12,032.64	2,967.36					
Wyoming	15,000	11,665.00	1,374.45	2.45	86.27		777.42	105.28
Total	750,000	583,999.14	76,655.52	981.78	1,221.23	2,993.01	19,843.45	6,393.99

[1] Including balance of appropriation from previous year, $2,609.49.

the act of Mar. 16, 1906 (Adams Act), for the year ended June 30, 1936

Expenditures—Continued										
Fertilizers	Feeds	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Travel	Contingent	Buildings and land	Balance
	$13.93		$42.59	$17.11	$789.86	$20.00	$64.33		$66.38	
$57.76		$15.98	82.21		65.97		1,538.52	$4.90	330.00	
40.00	274.60	19.24	6.99	121.15	851.45		338.09	5.00	714.98	
6.54		27.50	11.74	1.50	994.59		216.04			
	1,953.70	4.00	157.38	3.00	275.40		14.10		749.04	
72.53	77.29	8.75		13.70	923.18		81.77	17.00		
	1.95		1.90	2.40	16.82		207.89	11.44		
	193.39				908.85					
	324.95				237.61					
	552.37		7.08	25.05	106.89	139.13				
	99.05		3.88		87.35	17.00				
12.35	579.85		112.02	14.12	420.20	269.40	336.23		143.77	
	154.30				17.71					
			20.08	94.50	676.83		92.95			
					550.00					
		11.11	371.33	1.20	20.51	1.62	12.10		2.40	
100.32	2,478.39		241.92	21.76	322.38	235.00	24.84	2.90	290.98	
		17.90	72.33	342.07	691.15		872.25	4.90	50.00	
	48.98	1.00	10.50	4.46	42.50	293.30	490.03			
2.69	137.62		475.65	16.96	301.84	25.85	110.49	1.71	169.17	
		324.13	11.55	42.35	1,038.90		87.53	69.81	487.50	
98.03		23.74	224.47		283.75	25.00		83.06	211.66	
					7.95					
6.48			273.84		1,260.67		615.25		431.55	
	903.45		35.98		68.83	63.85				
	74.40				168.31	52.50	8.45			
	2,191.76		173.63	25.00	485.27		28.35		32.88	
		6.25	94.46	22.20	301.36		220.96	24.11		
149.19					258.00		3,340.32			$2,086.34
59.60	1,161.92		32.90		360.00					96.70
	300.00	122.87	497.22	156.11	1,176.59		334.05		234.73	
	202.15	92.65	48.95	543.14	890.20	44.25	779.77			
		20.99	63.78	157.47	302.02		161.51		40.00	
	3.00	12.25	119.74	484.20	313.04	386.00	359.13	2.40	29.22	
24.38		58.53	68.23	73.39	897.40		38.48		11.32	
22.30	1,961.56		53.43	20.45	480.61	307.00		.31	6.00	
	4.00	132.60	90.50		152.54		154.24			
			71.50	30.00	389.10		12.05			
	206.42			73.53		307.95	401.23			
$652.17	13,899.03	899.49	3,477.78	2,306.82	17,135.63	2,187.85	10,940.95	227.54	4,001.58	2,183.04

TABLE 7.—*Expenditures from Federal appropriations received under*

Station	Amount of appropriation	Expenditures							
		Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, water, light, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$60,000	$38,916.94	$10,058.17	$156.04	$303.59	$200.54	$988.23	$2,115.90	$795.27
Arizona	60,000	38,993.77	6,600.90	1,240.74	95.97	66.21	497.78	3,279.63	1,258.20
Arkansas	60,000	40,327.92	4,707.86	3,409.31	894.41	111.79	205.00	636.42	559.60
California	60,000	60,000.00							
Colorado	60,000	45,714.36	7,455.90	785.00	444.87	6.85	239.39	724.32	213.20
Connecticut:									
State	30,000	25,266.99	1,359.43		180.72	13.30	687.04	709.84	185.31
Storrs	30,000	24,303.54	2,561.01	21.67	766.54	2.65		357.83	27.24
Delaware	60,000	40,295.90	8,147.78	1,154.56	50.96	76.01	546.58	852.21	391.77
Florida	60,000	40,364.98	10,955.02	.85	177.73	.88	55.03	2,902.23	649.31
Georgia	60,000	35,828.50	8,257.80	918.97	484.38	803.26	2,515.12	1,297.72	582.12
Idaho	60,000	39,414.82	6,400.22	255.44	383.85	148.90	184.25	2,158.75	225.70
Illinois	60,000	36,995.06	9,772.21	2,223.48	798.35	69.43		1,422.54	28.07
Indiana	60,000	42,079.28	6,706.15	452.99	461.04	63.28		973.39	37.44
Iowa	60,000	59,282.89							
Kansas	60,000	37,500.00	18,013.64	24.14	77.16	17.56	6.11	1,878.37	298.51
Kentucky	60,000	47,954.34	5,494.81	1,984.97	72.00	25.49	32.49	508.01	355.47
Louisiana	60,000	42,441.51	10,151.50	252.08	196.99	127.93	110.54	315.75	457.58
Maine	60,000	44,556.31	6,258.41	.85	239.92	96.20	451.93	898.81	415.76
Maryland	60,000	44,333.37	4,045.86	2,790.26	114.59	76.98		1,767.73	530.45
Massachusetts	60,000	53,338.43	2,744.92	74.13	147.23		24.00	815.57	159.28
Michigan	60,000	42,180.28	6,475.53	4,150.52	611.11	3.98	49.98	1,575.20	139.26
Minnesota	60,000	48,211.81	1,481.27	982.67	106.67	160.25		773.66	1,399.50
Mississippi	60,000	38,793.44	11,575.73	91.20	743.58	227.72	1,589.20	641.94	769.13
Missouri	60,000	18,992.78	16,847.24	2,089.17	394.66	526.08	313.69	4,969.40	823.59
Montana	60,000	32,236.43	16,750.22	1,581.14	881.90	39.25	239.07	1,085.64	369.64
Nebraska	60,000	39,528.86	12,121.88	705.84	54.68	46.98	22.24	580.76	442.65
Nevada	60,000	29,725.04	14,093.99	512.39	1,047.82	283.18	243.28	843.89	1,330.01
New Hampshire	60,000	42,216.80	6,929.06	559.26	259.44	100.86	1.21	993.76	754.08
New Jersey	60,000	48,175.50	4,329.24		142.18	1.55	260.51	1,736.71	488.58
New Mexico	60,000	29,760.17	10,832.99	2,399.34	706.14	142.51	698.24	920.75	503.95
New York:									
Cornell	54,000	46,949.01	383.56		751.58	1.11		1,051.84	51.74
State	6,000	4,500.00	1,212.90		28.64			25.57	
North Carolina	60,000	37,570.85	8,790.30	579.33	585.37	74.79	86.76	642.45	419.63
North Dakota	60,000	36,157.59	8,814.67	324.17	243.64			1,417.29	247.32
Ohio	60,000	38,177.58	11,643.02	456.97	92.90		731.01	377.07	260.07
Oklahoma	60,000	29,215.77	16,384.12	320.69	527.59	22.52		786.84	693.63
Oregon	60,000	37,893.67	11,177.82	2,120.50	484.01	94.63	67.68	988.62	573.52
Pennsylvania	60,000	45,746.40	4,319.03	1,176.07	215.06	31.41	160.90	1,232.20	188.86
Rhode Island	60,000	39,639.80	10,968.31	421.75	71.11	53.21	725.06	1,419.59	194.88
South Carolina	60,000	37,575.60	10,702.69	511.54	708.45	144.31	357.86	1,127.15	222.40
South Dakota	60,000	31,178.95	14,167.16	2,292.72	1,678.64	158.88	76.77	1,229.39	343.06
Tennessee	60,000	42,924.71	7,964.94	759.37	342.40	285.84	263.14	1,419.06	626.58
Texas	60,000	39,638.16	12,331.75		459.61	65.27	326.87	1,195.87	215.47
Utah	60,000	33,064.33	15,378.02	2,145.38	443.10	131.91	52.71	1,053.13	1,036.45
Vermont	60,000	34,503.50	8,879.51	391.07	892.24	124.63	2,184.12	1,505.71	549.57
Virginia [1]	60,000	36,985.81	13,370.87	2,986.49	391.87	13.43	63.97	226.27	404.03
Washington	60,000	37,909.12	11,160.24	1,820.61	394.44	9.27	17.55	667.45	841.47
West Virginia	60,000	37,261.66	10,180.52	288.85	45.25	126.46	314.83	1,348.81	351.81
Wisconsin	60,000	46,932.71	11,683.60	8.85	22.40	.50		160.23	
Wyoming	60,000	38,863.23	4,760.98	792.08	300.41	281.17	294.95	1,285.20	476.40
Total	2,880,000	1,940,418.47	425,402.75	46,213.45	19,517.19	5,058.96	15,685.09	56,896.47	21,887.56

[1] Including balance of appropriation from previous year, $5.73.

the act of Feb. 24, 1925 (Purnell Act), for the year ended June 30, 1936

Expenditures—Continued										
Fertilizers	Feeds	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Travel	Contingent	Buildings and land	Balance
$119.05	$2,377.18	$156.60	$228.77	$226.28	$2,861.12	$320.00	$123.00	$31.07	$22.25	------
574.29	904.92	17.25	1,192.97	214.49	1,241.05	45.18	3,692.47	84.18	------	------
20.00	19.77	213.45	81.26	466.50	1,764.76	------	2,229.11	11.08	4,341.76	------
57.00	95.65	143.27	476.59	211.96	1,760.41	65.50	1,536.94	.60	68.19	------
215.31	------	------	502.17	33.05	330.86	------	388.97	12.58	114.43	------
------	56.59	31.44	55.57	386.47	548.13	15.45	725.08	140.79	------	------
133.73	2,445.61	233.77	339.80	262.97	1,181.70	------	3,288.68	227.22	370.75	------
------	412.35	19.54	73.37	388.76	617.57	261.83	3,011.96	53.91	54.68	------
168.56	3,418.38	201.52	883.20	236.10	673.22	285.00	2,056.63	7.50	1,382.02	------
56.14	3,259.79	124.70	48.70	275.01	1,518.54	32.50	2,178.74	45.79	3,288.16	------
------	115.21	160.42	1,071.88	621.64	3,454.00	------	3,180.42	30.27	57.02	------
------	99.70	13.50	637.47	539.68	2,496.82	------	5,338.58	46.68	54.00	------
------	------	------	------	------	717.11	------	------	------	------	------
------	1,082.79	------	288.13	37.10	553.43	29.54	138.42	11.00	44.10	------
------	573.55	75.17	------	156.93	320.23	------	2,446.54	------	------	------
419.06	1,243.03	38.90	854.17	282.95	859.09	127.58	1,802.90	46.04	272.40	------
1,409.08	903.25	25.00	1,734.78	538.85	883.16	186.40	1,217.16	101.48	82.65	------
703.19	------	37.13	816.78	120.03	278.47	774.61	3,339.75	------	270.80	------
------	552.04	127.60	25.43	124.57	575.93	3.60	1,264.93	22.34	------	------
85.72	211.11	465.86	13.75	582.07	760.37	------	2,695.26	------	------	------
------	1,243.41	16.20	195.69	642.85	2,672.62	773.76	1,304.63	35.01	------	------
299.12	938.98	105.01	2,076.34	221.64	1,071.39	7.00	453.10	89.53	305.95	------
------	5,727.01	20.23	2,603.08	753.48	1,643.61	763.50	1,163.21	168.90	2,200.37	------
120.81	959.08	144.30	1,033.45	617.29	255.13	261.80	3,294.85	.82	129.18	------
13.12	4,324.35	79.19	140.82	255.23	746.54	221.60	694.44	.33	20.49	------
------	2,835.09	60.96	941.02	376.02	228.58	460.70	3,660.18	34.15	3,323.70	------
537.44	571.29	10.00	523.42	1,284.79	1,791.70	9.24	3,239.77	44.61	173.27	------
127.29	191.26	107.05	479.50	719.60	1,568.55	31.60	899.46	149.84	591.58	------
222.39	4,503.01	26.46	1,632.50	1,487.44	346.07	1,658.10	2,799.16	518.52	842.26	------
------	16.75	1.00	769.18	171.65	2,645.94	------	1,168.41	38.23	------	------
------	------	14.63	------	------	81.90	------	40.54	------	------	$95.82
187.58	4,374.76	11.48	440.97	84.78	1,582.81	1,162.00	2,158.55	14.48	1,233.11	------
------	9,253.51	11.02	969.97	129.25	679.05	161.90	1,397.57	3.33	183.86	5.86
------	4,433.03	20.18	94.25	44.03	1,096.59	2,185.50	387.80	------	------	------
15.00	5,757.66	14.10	998.34	594.79	1,702.32	234.00	596.57	30.29	2,105.77	------
------	240.12	6.65	800.58	1,143.32	215.59	------	3,915.57	185.56	92.16	------
101.72	1,549.59	------	1,520.63	13.03	2,039.24	64.40	1,574.46	67.00	------	------
234.27	2,471.85	92.33	1,575.39	269.85	630.95	------	1,047.88	9.75	148.77	25.25
347.42	2,076.23	216.50	1,254.27	477.91	2,026.56	------	1,961.79	4.41	284.91	------
------	1,994.30	300.63	493.78	920.37	1,077.93	5.00	1,865.48	25.12	2,191.82	------
170.78	520.20	317.99	791.04	430.43	1,335.45	21.70	974.97	33.97	817.43	------
------	452.28	134.65	372.11	508.28	2,563.87	57.50	1,348.48	12.68	317.15	------
17.94	505.22	292.42	194.44	275.75	113.03	------	4,412.56	34.18	849.43	------
------	797.76	36.72	2,256.96	1,016.69	1,153.10	278.42	3,207.34	523.32	1,699.34	------
13.99	92.15	84.33	1,526.95	754.44	1,491.21	11.70	1,510.80	------	71.69	------
53.35	1,284.82	126.66	376.62	529.42	258.69	1,688.32	2,204.91	10.67	646.39	------
173.34	2,214.42	------	1,053.26	268.60	1,839.76	509.12	2,788.64	4.63	1,230.04	------
------	------	------	------	93.15	280.75	2.25	815.56	------	------	------
------	8,579.76	113.64	444.07	160.01	1,368.62	520.00	1,632.00	------	127.48	------
6,596.69	85,678.81	4,449.45	34,883.42	19,949.50	57,903.52	13,236.30	93,174.22	2,911.86	30,009.36	126.93

TABLE 8.—*Expenditures from Federal appropriations received under the act*

Station	Amount of appropriation	Expenditures							
		Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, water, light, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$20,673.78	$3,454.44	$1,292.23		$21.54	$283.56	$25.00	$655.63	$724.92
Alaska	559.12	67.35	307.37		9.25	37.05			113.10
Arizona	3,105.64	1,574.94	671.00		86.57	.77			24.96
Arkansas	15,995.80	8,579.46	446.38		69.37	9.48		706.83	263.17
California	16,485.49	16,485.49							
Colorado	5,607.74	1,099.98			339.93			19.35	2.85
Connecticut:									
State	2,582.26	1,430.67	152.80		72.02		265.98	211.42	2.70
Storrs	2,582.26	1,512.06	370.18		8.25			26.46	.99
Delaware	1,252.55	1,000.04	6.00			1.78		94.35	.76
Florida	7,700.41		213.00		70.65			115.57	40.61
Georgia	21,880.73	4,829.97	3,024.73		62.85	137.39	404.07	640.53	312.43
Hawaii	2,296.60	800.00				113.82		394.00	35.77
Idaho	3,429.64	2,598.55	314.18		2.40			127.25	21.01
Illinois	21,684.13	3,384.92	2,486.44	$4.99	18.15	234.30		763.91	106.22
Indiana	15,680.65	3,770.00	310.91		35.95	5.20		958.06	147.47
Iowa	16,213.66	16,010.30							
Kansas	12,512.74	5,762.49	2,457.93	6.60	9.30	34.48		432.99	147.79
Kentucky	19,734.51	1,133.34						132.13	69.86
Louisiana	13,783.36	8,385.02	1,542.41		68.93	33.94	47.89	541.66	257.37
Maine	5,173.04	5,173.04							
Maryland	7,137.62	3,682.36	258.45		58.30			191.98	56.54
Massachusetts	4,545.55	4,514.25							
Michigan	16,741.96	10,733.46	619.42		1.28	7.74		720.86	253.70
Minnesota	14,199.41	280.50	2,068.79			80.04		148.40	1,093.15
Mississippi	18,162.85	7,358.72	3,099.09		93.25	96.20	569.22	567.53	1,073.20
Missouri	19,241.95	5,496.43	2,878.78		257.61	61.08	258.52	983.05	480.63
Montana	3,875.79	1,633.86	1,618.47		2.25	6.26		53.08	28.34
Nebraska	9,694.15	5,083.28							
Nevada	615.16	350.00							22.27
New Hampshire	2,089.30	1,411.43	294.69		2.05	15.98			106.64
New Jersey	7,631.46	3,312.50	728.71				1,270.06	605.85	274.18
New Mexico	3,440.25	783.32	329.49		12.68	39.76	39.17	125.10	196.20
New York:									
Cornell	20,212.12	10,158.92	855.02		49.83	62.40	11.11	606.87	414.37
State	2,245.79	1,458.35		36.50				78.80	60.71
North Carolina	25,657.00	12,542.41	1,424.61	7.85	22.04	43.14	41.37	1,118.67	224.88
North Dakota	6,168.94	6,043.23	70.00		3.45			1.95	
Ohio	23,253.69	16,583.40	832.60		49.11	27.18		759.89	149.83
Oklahoma	17,112.71	4,833.38	3,415.22		49.95	95.88	4.89	905.61	477.84
Oregon	5,043.95	2,521.10	1,652.25		76.08	.48		35.55	
Pennsylvania	33,672.38	22,953.62	3,535.91		111.11	32.11	101.11	484.21	82.56
Puerto Rico	12,138.04	2,217.45	1,208.99			62.83		1,753.85	284.20
Rhode Island	565.96	565.96							
South Carolina	14,866.24	2,865.00	1,758.77		10.96	205.41	24.87	1,177.42	174.40
South Dakota	6,108.11	925.00	1,717.79		26.25	187.20	17.68	47.45	395.70
Tennessee	18,695.97	6,375.00	5,102.50		160.32	187.22	127.77	36.18	542.80
Texas	37,341.19	10,336.66	9,675.22		558.34	30.10		683.36	130.64
Utah	2,625.92		1,331.00		86.65				64.62
Vermont	2,617.90	2,614.17	3.73						
Virginia	17,786.14	5,422.43	1,529.93	3.20	24.43	49.58	2.50	170.02	1,411.81
Washington	7,378.93	4,250.77	2,075.05		10.26	5.49		137.69	158.93
West Virginia	13,453.36	6,358.35	3,994.61	17.79		29.53	65.50	1,171.73	3.75
Wisconsin	15,056.22	12,340.04	2,630.22					23.04	
Wyoming	1,689.88	668.00							
Total	600,000.00	263,725.41	68,304.87	76.93	2,541.36	2,217.38	3,276.71	18,408.28	10,433.87

of June 29, 1935 (Bankhead-Jones Act), for the year ended June 30, 1936

Expenditures—Continued										
Fertilizers	Feeds	Library	Tools, implements and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Travel	Contingent	Buildings and land	Balance
$36.75	$376.21		$1,457.68	$377.82	$7,207.83	$282.70	$743.99		$3,733.48	
25.00										
		$35.00		552.39			160.01			
7.50	43.73	59.56	42.37	447.74	4,496.22		639.79		184.20	
			2,025.34		2,089.44		30.85			
			243.55	4.21			174.68		24.23	
		42.33		139.98	3.82		478.19			
		30.69		11.80	90.85		16.28			
38.48			16.00		225.00		20.95		6,960.15	
53.41	3,954.54	35.05	1,431.25	489.51	735.50	247.50	549.04	$30.00	4,942.96	
					123.90		82.00	1.00	746.11	
	11.13				60.95		194.17		100.00	
	82.01		1,095.32	142.92	9,102.15	2,246.66	851.72	2.95	852.69	$308.78
2.10			65.92	76.76	6,349.56		1,721.25			2,237.47
	119.57			83.79						
	580.74		437.44	32.50	753.81	48.33	73.00		1,735.34	
93.71		1.25		625.01			184.21		17,495.00	
10.00	156.85	5.04	937.70	590.70	863.14	25.29	317.42			
99.45			711.78		154.81		463.95		1,460.00	
							31.30			
73.63			656.21	78.79	3,450.47		91.40		55.00	
3.60	470.04		3,967.44		1,249.35	1,456.14	621.75	10.00	2,750.21	
1.75	180.75	3.00	1,925.99	53.83	1,117.67	200.00	273.63	24.23	1,524.79	
	350.08	23.75	441.30	322.84	599.47	65.00	1,078.89	18.40	5,926.12	
31.88	114.80		157.58			96.25	133.02			
							38.87		4,572.00	
				50.63	123.50		64.76		4.00	
71.80		2.70	18.40		101.47		49.14		15.00	
				270.35	486.27	145.00	336.57		201.97	
	74.00	6.00	536.55	1.13	362.22		91.97		842.66	
	596.00		2,887.05	109.35	2,593.96	330.00	929.31		607.93	
				128.66	384.19		98.46			.12
53.36		27.00	123.19		4,234.75		1,550.86	1.76	4,241.11	
							50.30			.01
	231.56	1.50	623.56	28.75	2,477.10	44.00	236.02		1,209.19	
	1,578.70	5.00	1,421.95	196.02	311.37	350.00	164.97		3,301.93	
			6.00		118.50		633.99			
659.41	314.22		193.31	405.20	1,099.77	35.00	2,645.84		1,019.00	
55.95			53.00	44.25	2,853.39			92.98	400.25	3,110.90
119.54	100.00	8.00	1,316.20	118.91	2,145.62		720.10		4,121.04	
	1,140.61	3.00	534.17	279.42	213.83	475.79			144.22	
174.49	168.70		2,295.72	74.69	220.54	1,095.00	347.19	63.50	1,724.35	
	237.59	64.06	22.45	732.98	9,179.64		1,194.27	5.00	4,490.88	
			617.85		5.46		520.34			
159.17	76.05	58.53	953.75	438.28	2,881.90	30.00	793.49	5.24	3,775.83	
4.29	163.07	1.00		31.25	225.55	83.25	232.33			
370.60	97.00		238.53	124.82	555.39	78.25	147.51		200.00	
							62.92			
			599.85		62.37		359.66			
2,145.87	11,217.95	412.46	28,054.40	7,065.28	69,310.73	7,334.16	20,200.36	255.06	79,361.64	5,657.28

TABLE 9.—*Expenditures from supplementary funds received from within the States for the year ended June 30, 1936*

Station	Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, water, light, and power	Chemical supplies	Seeds, plants, and sundry supplies	Fertilizers	Feeds
Alabama	$51,552.35	$28,472.54	$1,347.19	$2,277.07	$1,661.79	$6,921.89	$84.63	$8,981.97	$4,523.79	$5,866.54
Alaska	1,188.77	2,590.36	287.18	84.79	213.78	290.75	125.65	751.14	147.80	
Arizona	45,322.63	18,660.26	3,060.43	1,919.20	132.38	1,827.42	1,424.75	2,685.06	320.70	9,815.95
Arkansas	33,081.15	15,160.62		1,902.32	267.08	4,589.98	4,052.86	102.44	953.13	3,104.04
California	370,707.03	148,282.79	18,535.36	16,681.84	5,560.59	19,462.12	17,608.59	33,363.64	6,487.37	41,704.55
Colorado	43,949.23	25,524.57	3,155.05	2,771.24	1,391.68	6,770.47	1,456.54	3,829.39		7,711.06
Connecticut:										
State	123,283.27	61,052.86	455.35	4,347.60	119.96	5,723.45	2,732.92	2,275.57	1,526.49	292.55
Storrs	20,633.39	12,586.42	92.14	871.75	898.13	403.16	1,545.89	672.49	271.82	2,887.11
Delaware	5,019.24	12,878.49		737.82	352.05	4,412.16	110.71	2,508.84	347.62	5,490.51
Florida	176,883.18	65,139.27	7,751.80	5,549.53	1,732.60	10,972.54	5,965.18	8,830.71	5,717.86	12,422.47
Georgia	3,055.18	3,079.62	396.93	354.33	763.25	4,030.29	106.78	5,626.70	158.78	77.93
Hawaii	13,896.35	5,558.54	217.36	1,153.96	202.68	1,321.67	1,244.19	2,916.29	447.52	2,738.28
Idaho	9,748.28	4,870.87		472.71	246.18	1,309.91	940.57	786.63		1,824.75
Illinois	214,577.76	82,098.09	9,482.68	4,781.91			11,727.93	23,465.10	4,691.17	29,329.85
Indiana	189,890.30	117,993.77	2,973.88	39,030.02	3,403.27	12,950.97	23,292.19	8,368.43	11,217.10	29,860.09
Iowa	138,156.79	33,961.94	18,951.77	3,709.44	1,393.59	572.93	5,885.11	13,890.16	472.33	14,101.46
Kansas	29,764.00	56,514.18	1,525.39	3,512.56	1,532.62	6,350.05	4,321.55	6,268.43	90.49	13,909.83
Kentucky	134,764.58	48,785.43	504.92	4,168.64	783.92	6,091.19	2,121.88	17,683.22	837.09	12,573.50
Louisiana	53,641.28	23,575.31	321.20	1,889.24	552.24	3,808.18	1,698.42	2,968.97	1,389.64	2,401.02
Maine	22,607.84	14,317.63	50.07	667.98	604.01	3,674.53	1,129.37	2,066.73	156.19	849.10
Maryland	29,629.47	21,063.59	1,306.85	1,830.30	1,612.52	3,064.54	1,535.97	4,140.76	1,192.83	8,779.50
Massachusetts	111,816.00	34,671.64	3,382.56	2,386.79	1,080.96	1,218.64	4,258.48	3,377.95	984.30	6,184.78
Michigan	118,652.85	63,776.50	16,100.34	2,457.17	981.71	3,398.03	7,154.19	8,487.56	2,006.89	9,177.27
Minnesota	212,707.39	85,296.33	1,556.63	6,666.58	1,518.00	16,591.85	13,863.61	5,723.51	2,533.42	11,755.19
Mississippi	36,080.45	30,466.92	394.66	3,228.15	1,539.05	5,701.02	64.05	17,268.99	660.04	3,420.40
Missouri	35,393.84	30,513.62	4,468.87	2,724.84	760.77	1,478.78	9,338.57	8,573.37	854.94	6,868.65
Montana	56,847.65	19,228.03	814.84	3,376.99	201.47	3,743.97	1,249.72	8,606.61	359.67	10,056.29
Nebraska	64,737.25	28,156.89	1,466.64	2,754.45	964.32	8,031.09	9,236.91	1,246.69	5,316.72	27,087.14
Nevada	285.00	1,217.39		190.69	51.13	1,365.21	33.05	237.81		
New Hampshire	17,327.70	4,511.15	205.37	1,277.81	123.92	160.98	2,341.62	1,318.53		244.41
New Jersey	315,505.95	13,813.36	6,228.87	10,848.95	697.58	16,050.21	9,220.61	870.49	1,340.62	28,117.53
New Mexico	5,818.49	4,531.89	678.65	374.62	370.82	946.21	514.20	563.61	6.30	1,773.64
New York:										
Cornell	396,256.86	58,315.13	14,639.32	11,488.05	1,583.04	22,444.26	18,586.37	18,499.12		16,776.52
State	212,906.64	53,031.55	9,737.42	5,251.57	2,317.38	15,916.25	5,583.00	5,817.05	788.88	7,898.52
North Carolina	37,781.74	36,497.28	178.95	1,592.48	517.86	3,844.03	4,798.56	1,168.89	3,504.52	8,323.25
North Dakota	13,628.79	2,640.32	1,884.95	1,312.26	532.22	9,700.58	830.60	1,363.54	25.52	4,432.08
Ohio	209,273.59	91,460.91	28,073.50	4,691.21	2,708.39	23,367.41	2,443.70	22,978.73	1,021.74	25,893.03
Oklahoma	59,512.30	10,000.74	979.67	1,506.62	846.74	194.30	1,799.62	3,022.63	1,268.82	7,022.73
Oregon	60,389.69	54,996.27	1,847.84	2,721.31	1,520.43	6,716.06	3,264.84	10,515.65	843.61	6,246.03
Pennsylvania	78,963.74	29,322.41	2,713.56	4,223.42	1,409.80		4,364.66	1,408.88	8,583.25	9,908.41

Puerto Rico	70,151.53	22,543.85	546.22	1,609.27	108.94	1,371.86	2,005.07	3,023.61	1,287.13	1,451.68
Rhode Island	2,812.69	1,792.22	31.92	206.87	50.54	236.72	300.58	223.76	47.53	166.76
South Carolina	41,263.25	31,518.14	491.14	1,838.90	1,428.10	2,082.82	13,247.37	5,366.19	1,959.12	10,605.46
South Dakota	9,933.00	4,913.69		234.64	155.65	529.52	73.59	1,100.09		4,395.26
Tennessee	16,453.12	6,862.30	267.59	746.46	422.31	923.75	2.90	1,676.48	231.93	3,330.80
Texas	258,021.51	77,936.72	8,376.16	9,320.56	1,443.24	7,981.74	7,268.13	33,899.60		25,462.93
Utah	12,398.21	16,226.75	1,591.68	2,200.22	253.23	473.47	226.06	1,672.96	9.50	2,017.39
Vermont	9,920.18	4,140.53	1,599.41	277.66	74.74	590.94	345.10	93.04		3,648.32
Virginia	51,129.95	12,726.57	1,550.21	1,697.81	434.49	1,145.37	1,532.68	2,022.06	1,168.53	3,273.18
Washington	37,309.61	39,674.16	693.05	1,337.31	592.90	3,215.65	3,472.15	5,168.45	482.85	5,967.69
West Virginia	27,971.76	18,682.52	740.48	1,162.23	215.08	3,534.35	343.44	10,334.95		4,097.32
Wisconsin	162,894.93	65,157.97	8,144.75	7,330.27	2,443.42	8,551.98	7,737.51	14,660.54	2,850.66	18,325.68
Wyoming	55,086.40			2,532.33	858.09		2,671.03	5,073.34	1,001.43	6,059.81
Total	4,510,584.13	1,756,790.90	189,800.80	198,282.74	51,630.64	276,055.25	227,283.65	357,547.35	80,087.64	485,728.24

TABLE 9.—*Expenditures from supplementary funds received from within the States for the year ended June 30, 1936*—Continued

Station	Library	Tools, implements and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Travel	Contingent	Buildings and land	Balance	Total
Alabama	$74.57	$9,790.43	$585.24	$281.45	$8,668.26	$6,197.99	$3,970.97	$25,242.78	$103,657.09	$270,158.54
Alaska	24.31	274.52	18.00	161.30	20.40	83.75	10.50	1,058.40	1,302.10	8,633.50
Arizona	3.76	2,891.69	1,830.15		165.00	3,980.06	828.97	2,208.60	3,221.41	100,298.42
Arkansas	692.06	2,492.10	548.26	1,935.78	372.47	2,055.68	7,985.74	2,231.00		81,526.71
California	3,707.08	22,242.42	6,487.38	11,121.21	13,901.51	32,436.87	12,047.98	63,020.20	83,409.09	926,767.62
Colorado	1,027.08	8,555.65	1,494.94	1,177.86	6,440.30	6,115.03	1,038.86	9,391.29	49,263.40	181,063.64
Connecticut:										
State	2,175.51	10,596.10	1,009.41	1,272.85		13,065.87	1,598.94	2,233.48	1,303.72	235,065.90
Storrs	784.77	689.38	543.92	400.22	44.58	936.26	57.60			44,319.03
Delaware	66.31	1,166.55	54.15			318.01	639.48	2,195.80	4,483.52	40,781.26
Florida	2,394.45	13,542.31	4,591.27	5,372.10	1,896.55	13,899.24	3,750.96	15,311.41	61,607.41	423,330.84
Georgia	634.23	946.25	207.28	351.56	507.85	1,482.74	1,251.48	7,216.88	9,545.28	39,793.34
Hawaii	59.58	357.60	94.86	178.80	521.00	808.54	2,546.16	2,331.80	1,108.22	37,703.40
Idaho		3,376.17		782.02		772.16	1,961.93	7,741.85	1,939.10	36,773.13
Illinois	1,231.48	14,833.96	2,052.46	3,694.43	4,622.71	10,467.82				417,057.35
Indiana	2,474.06	15,982.61	3,873.31	3,346.47	4,026.32	24,161.07	9,488.10	19,982.20	295,417.91	817,732.07
Iowa	14.95	1,604.22		3,084.75	3,018.12	8,634.30	921.55	439.85	16,861.75	265,675.01
Kansas	69.47	18,405.86	3,287.64	8,332.70	4,480.29	5,312.85	560.97	12,172.42	15,855.29	192,266.59
Kentucky	1,946.90	2,143.63	1,267.39	2,338.57	2,685.78	10,432.22	2,396.30	34,585.31	8,855.07	294,965.54
Louisiana	55.91	4,807.53	2,181.52	1,032.15	2,783.63	5,355.59	1,568.23	2,335.41	5,511.11	117,876.58
Maine	1,514.71	3,434.88	143.28	515.44	117.40	2,715.73	257.95	553.48	983.47	56,359.79
Maryland	254.66	3,156.34	138.31	472.19	930.00	2,974.23	3,198.47	2,851.80	24,092.98	112,225.31
Massachusetts	1,133.03	2,285.61	1,911.50	2,482.51	456.78	5,908.58	347.17	5,481.78	69,517.90	258,886.96
Michigan	1,634.82	7,777.52	1,001.85	4,014.09	3,056.98	11,686.77	2,653.29	2,046.74		266,064.57
Minnesota	1,992.74	12,417.87	2,365.95	2,553.23	3,833.33	5,288.26	3,961.30	39,654.58		430,279.77
Mississippi	296.84	2,594.37	1,698.38		13,527.46	3,472.23	261.39	17,419.66	23,100.32	161,194.38
Missouri	381.85	4,970.72	1,144.83	1,184.32	5,054.41	3,253.49	713.47	9,226.03	29,863.97	156,769.34
Montana	78.95	278.16	128.98	198.50	2,646.05	1,962.38	113.16	594.31	25,093.47	135,579.20
Nebraska	233.33	7,763.86	7,339.75	3,772.37	8,919.42	2,739.79	1,246.81	3,901.12		184,914.55
Nevada	359.53	809.25	158.25			2,203.04	1,933.25	3,430.45	1,083.02	13,357.07
New Hampshire	98.23	1,266.16	138.22	48.25	100.00	4,095.41	9,795.47	2,156.56	13,004.81	58,214.60
New Jersey	924.83	9,272.37	398.04	1,000.94		14,651.52	18,038.05	3,643.82	4,568.76	455,192.50
New Mexico	240.10	480.10	30.00	49.94	219.00	508.28	154.42	4,586.59	32,570.77	54,417.63
New York:										
Cornell	2,565.78	10,381.11	3,586.22	17,615.91	2,582.99	20,920.93	3,152.56	5,813.19		625,207.36
State	3,683.23	11,993.15	1,054.94	1,352.37	1,690.46	7,406.90	2,657.58	17,843.83	10,142.78	377,073.50
North Carolina	69.97	7,988.52	122.28	160.95	2,564.68	8,612.71	1,830.10	18,975.21	6,231.68	144,763.66
North Dakota	213.74	2,571.52	125.17	369.55	4,028.82	2,362.85	536.22	8,685.00	47,203.26	102,446.99
Ohio	890.88	2,706.48	116.63	57.03	5,421.22	5,864.60		13,083.20	375,154.67	815,215.92
Oklahoma	976.37	2,375.32	981.61		9,694.02	4,472.95	13,830.43	5,034.64	19,094.43	142,613.94
Oregon	140.37	4,863.93	441.12	240.18	4,173.58	5,062.74	3,564.05	5,431.69	56,922.95	229,842.34
Pennsylvania	296.95	1,806.80	550.09	900.89	1,127.36	8,105.27			2,154.08	155,839.57

Puerto Rico	762.69	4,046.07	1,165.90	1,110.61	105.32	1,395.55	897.58	3,193.12	4,579.00	121,355.00
Rhode Island	14.00	443.63		27.64		264.83	22.00	202.28	1,554.95	8,398.92
South Carolina	77.39	6,674.51	3,071.64	9,359.52	6,182.70	2,575.56		4,768.72	15,497.06	158,007.59
South Dakota	37.90	466.96	99.18		5,754.20	1,416.38	109.73	450.27	16,028.59	45,698.65
Tennessee	324.95	1,886.81	121.17	20.39	357.63	364.64	1,347.38	2,937.61		38,278.22
Texas	1,576.81	7,500.80	2,560.46	3,852.71	12,706.88	23,163.64	36,043.74	17,249.29	77,395.90	611,760.82
Utah	503.46	1,044.66	1,130.28	68.55	1,501.88	3,736.67	773.10	5,215.56	5,467.37	56,511.00
Vermont	121.24	10.00	15.15	255.55		1,883.99	135.29	337.49	784.74	24,233.37
Virginia	656.28	1,715.84	912.15	1,393.36	605.51	5,349.77	1,135.84	4,514.94		92,964.54
Washington	1,030.47	3,861.58	337.03	106.20	796.12	3,140.91	302.19	8,772.34		116,260.66
West Virginia	220.30	1,294.91	341.51	667.93	833.20	543.61	943.67	45.00	15,654.34	87,626.60
Wisconsin	1,628.95	9,773.70	2,850.66	4,886.85	6,108.56	14,253.30	5,294.09	27,692.16	36,651.36	407,237.34
Wyoming	297.49	1,777.96	519.16	892.43	1,115.54	1,894.28			44,819.29	124,598.58
Total	42,678.32	276,330.45	66,826.87	104,494.62	160,366.27	330,767.84	167,874.47	455,491.14	1,622,557.39	11,361,178.71

TABLE 10.—*Experiment station expenditures for additions to equipment for the year ended June 30, 1936*

Station	Buildings	Library	Apparatus	Farm implements	Livestock	Miscellaneous	Total
Alabama	$28,216.21	$659.79	$9,983.81	$11,616.12	$9,113.12	$1,255.03	$60,844.08
Alaska	527.02	219.42	452.52	27.27	1,644.52	227.65	3,098.40
Arizona	11,269.81		5,181.49	3,660.32	3,397.18	1,559.99	25,068.79
Arkansas	7,619.79	992.17	9,165.23	2,492.10	372.47		20,641.76
California	38,635.38	7,000.00	5,918.47	6,155.20	3,314.34	8,285.85	69,309.24
Colorado	9,459.00	1,170.00	5,028.00	11,058.00	6,506.00	1,039.00	34,260.00
Connecticut:							
State		1,968.28	1,538.48	8,549.37		865.79	12,921.92
Storrs		876.94	1,624.15	836.96	118.92	1,099.82	4,556.79
Delaware	2,000.00	1,183.00	2,267.00	1,350.00		900.00	7,700.00
Florida	22,326.24	2,413.99	6,214.67	13,589.68	2,158.38	8,784.90	55,487.86
Georgia	7,361.52	1,618.62	2,069.92	1,000.00	1,576.48		13,626.54
Hawaii	3,077.91	375.96	8,911.68	2,750.15	741.40	13,810.68	29,667.78
Idaho	3,479.40	79.49	6,285.62	1,191.74	889.50	1,196.66	13,122.41
Illinois	6,079.98	759.99	3,039.99	3,230.00	1,709.99	4,179.98	18,999.93
Indiana	20,036.20	2,487.56	9,755.23	5,641.96	4,026.32	7,782.22	49,729.49
Iowa			8,828.79	157.00	316.16		9,301.95
Kansas	13,951.86	71.82	9,783.48	19,152.87	5,459.99	3,429.58	51,849.60
Kentucky	18,541.44	1,192.35	3,707.42	651.65	1,170.00		25,262.86
Louisiana	3,099.51	304.99	2,239.63	4,893.78	2,812.13	2,181.52	15,531.56
Maine	52.61	1,983.08	2,208.53	3,163.75	1,518.00	773.24	9,699.21
Maryland	1,730.80	291.79	1,410.96	4,468.41	1,704.61	352.84	9,959.41
Massachusetts	5,481.78	1,360.63	3,058.44	2,861.04		2,036.07	14,797.96
Michigan	1,000.00	1,000.00	6,331.50	1,968.75	442.00	2,023.00	12,765.25
Minnesota	8,598.70	2,186.74	7,021.41	17,516.22	6,632.21	3,434.94	45,390.22
Mississippi	66,143.90	3,846.30	22,244.44	13,046.50	25,661.50	20,155.71	151,098.35
Missouri	400,000.00	1,000.00	5,000.00	1,500.00	4,500.00		412,000.00
Montana	600.00	437.00	1,272.00	1,618.00	350.00		4,277.00
Nebraska	8,493.61	312.52	12,555.50	7,763.86	9,141.02	95,171.71	133,438.22
Nevada	10,939.39	253.54	1,952.21	161.00	164.61	618.70	14,089.45
New Hampshire	2,514.00	611.20	2,248.48	2,312.54	135.09	1,514.14	9,335.45
New Jersey		924.83	2,621.22	999.83			4,545.88
New Mexico	3,273.21	299.35	1,031.98	2,256.32	700.00	1,518.55	9,079.41
New York:							
Cornell	5,813.19	2,581.78	20,985.68	13,321.12	2,912.99	4,594.99	50,209.75
State		3,314.35	3,447.92	2,987.22	350.00	2,043.26	12,142.75
North Carolina	30,550.00	486.13	7,185.36	8,344.00	2,212.00	1,000.00	49,777.49
North Dakota	1,319.83	75.00	1,199.30	1,563.88	188.00	1,490.00	5,836.01
Ohio	2,884.88	941.81	3,878.88	6,474.73	7,703.22	290.66	22,174.18
Oklahoma	4,514.28	999.67	2,669.90	1,710.42	3,999.70	9,666.60	23,560.57
Oregon		158.27	907.57	3,006.50	4,173.58	1,736.64	9,982.56
Pennsylvania	1,019.00	1,232.50	3,915.74	1,656.55	500.00	933.69	9,257.48
Puerto Rico	1,000.00	297.52	5,991.34	1,998.24	475.00	2,796.25	12,558.35
Rhode Island	500.00	398.00	933.00	2,141.00		277.00	4,249.00
South Carolina	8,120.17	1,246.17	14,496.08	3,317.32	6,182.70	8,083.84	41,446.28
South Dakota		300.00	1,250.00	782.00	1,989.00	600.00	4,921.00
Tennessee	3,602.81	855.37	1,821.62	2,522.78	1,474.33	2,599.19	12,876.10
Texas	12,292.04	1,802.70	14,550.57	5,942.59	12,839.38	5,491.96	52,919.24
Utah	1,784.60	882.48	656.82	2,181.07	1,887.88		7,392.85
Vermont	656.77	337.50	2,363.22	2,116.63	278.42	1,379.06	7,131.60
Virginia	4,755.43	820.89	6,252.31	2,668.95	1,354.21	4,067.54	19,919.33
Washington	9,606.33	1,363.24	1,213.82	4,398.45	2,610.57	924.23	20,116.64
West Virginia			2,894.92	5,111.01	1,855.54		9,861.47
Wisconsin	18,000.00	2,229.66	4,752.90	4,533.95	4,597.78	1,242.35	35,356.64
Wyoming	8,026.31	500.00	1,903.90	1,773.96	2,103.40	3,867.07	18,174.64
Total	818,954.91	58,704.39	274,223.10	236,192.76	155,963.64	237,281.90	1,781,320.70

TABLE 11.—*Disbursements from the U. S. Treasury to the States and Territories and Puerto Rico for agricultural experiment stations under the acts of Congress approved Mar. 2, 1887, Mar. 16, 1906, Feb. 24, 1925, May 16, 1928, Feb. 23, 1929, and June 29, 1935*

State or Territory	Hatch Act		Adams Act		Purnell Act		Bankhead-Jones Act
	1888–1935	1936	1906–35	1936	1926–35	1936	1936
Alabama	$718,946.42	$15,000.00	$416,619.89	$15,000.00	$500,000.00	$60,000.00	$20,673.78
Alaska	66,000.00	15,000.00					559.12
Arizona	684,803.10	15,000.00	419,955.61	15,000.00	500,000.00	60,000.00	3,105.64
Arkansas	718,139.12	15,000.00	419,900.00	15,000.00	500,000.00	60,000.00	15,995.80
California	720,000.00	15,000.00	419,926.84	15,000.00	500,000.00	60,000.00	16,485.49
Colorado	719,718.82	15,000.00	418,638.93	15,000.00	500,000.00	60,000.00	5,607.74
Connecticut	720,000.00	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	5,164.52
Dakota Territory	56,250.00						
Delaware	718,382.87	15,000.00	415,475.12	15,000.00	496,924.01	60,000.00	1,252.55
Florida	719,966.04	15,000.00	419,996.06	15,000.00	496,523.74	60,000.00	7,700.41
Georgia	715,593.43	15,000.00	407,092.87	15,000.00	500,000.00	60,000.00	21,880.73
Hawaii	89,919.17	15,000.00	44,951.14	15,000.00			2,296.60
Idaho	644,324.13	15,000.00	415,842.22	15,000.00	500,000.00	60,000.00	3,429.64
Illinois	719,468.23	14,728.32	419,794.91	15,000.00	497,445.71	60,000.00	21,684.13
Indiana	719,901.19	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	15,689.65
Iowa	720,000.00	15,000.00	420,000.00	15,000.00	497,965.17	60,000.00	16,213.66
Kansas	719,995.00	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	12,512.74
Kentucky	719,996.57	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	19,734.51
Louisiana	720,000.00	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	13,783.36
Maine	719,999.62	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	5,173.04
Maryland	719,967.40	15,000.00	419,236.48	15,000.00	500,000.00	60,000.00	7,137.62
Massachusetts	719,617.70	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	4,545.55
Michigan	719,676.10	15,000.00	416,341.20	15,000.00	500,000.00	60,000.00	16,741.96
Minnesota	719,917.78	15,000.00	419,345.00	15,000.00	500,000.00	60,000.00	14,199.41
Mississippi	720,000.00	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	18,162.85
Missouri	715,097.24	15,000.00	419,999.90	15,000.00	500,000.00	60,000.00	19,241.95
Montana	630,000.00	15,000.00	417,417.04	15,000.00	500,000.00	60,000.00	3,875.79
Nebraska	719,932.16	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	9,694.15
Nevada	719,214.32	15,000.00	418,180.28	15,000.00	500,000.00	60,000.00	615.16
New Hampshire	720,000.00	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	2,089.30
New Jersey	719,949.97	15,000.00	419,392.06	15,000.00	500,000.00	60,000.00	7,631.46
New Mexico	684,509.05	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	3,440.25
New York	719,757.18	15,000.00	419,187.18	15,000.00	500,000.00	60,000.00	22,457.91
North Carolina	720,000.00	15,000.00	405,000.00	15,000.00	500,000.00	60,000.00	25,657.00
North Dakota	661,502.26	15,000.00	419,638.85	15,000.00	500,000.00	60,000.00	6,168.94
Ohio	720,000.00	15,000.00	418,514.02	15,000.00	500,000.00	60,000.00	23,253.69
Oklahoma	644,002.16	15,000.00	399,535.19	15,000.00	500,000.00	60,000.00	17,112.71
Oregon	705,156.64	15,000.00	415,000.00	15,000.00	500,000.00	60,000.00	5,043.95
Pennsylvania	719,967.43	15,000.00	419,995.41	15,000.00	500,000.00	60,000.00	33,672.38
Puerto Rico	15,000.00	14,950.17	10,000.00	12,390.51			12,138.04
Rhode Island	720,000.00	15,000.00	414,520.20	15,000.00	500,000.00	60,000.00	565.96
South Carolina	719,542.15	15,000.00	418,460.12	15,000.00	500,000.00	60,000.00	14,866.24
South Dakota	663,250.00	15,000.00	415,000.00	15,000.00	500,000.00	60,000.00	6,108.11
Tennessee	720,000.00	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	18,695.97
Texas	720,000.00	15,000.00	417,592.26	15,000.00	500,000.00	60,000.00	37,341.19
Utah	585,000.00	15,000.00	419,821.94	15,000.00	500,000.00	60,000.00	2,625.92
Vermont	720,000.00	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	2,617.90
Virginia	717,824.12	15,000.00	419,949.01	15,000.00	500,000.00	59,994.27	17,786.14
Washington	657,102.65	15,000.00	416,080.11	15,000.00	500,000.00	60,000.00	7,378.93
West Virginia	719,795.82	14,999.71	417,013.85	15,000.00	499,942.89	60,000.00	13,453.36
Wisconsin	720,000.00	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	15,056.22
Wyoming	705,000.00	15,000.00	420,000.00	15,000.00	500,000.00	60,000.00	1,689.88
Total	34,106,185.84	764,678.20	20,113,413.69	747,390.51	23,988,801.52	2,879,994.27	600,000.00

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